(54) Title: SHARED CHANNEL STRUCTURE, ARQ SYSTEMS AND METHODS
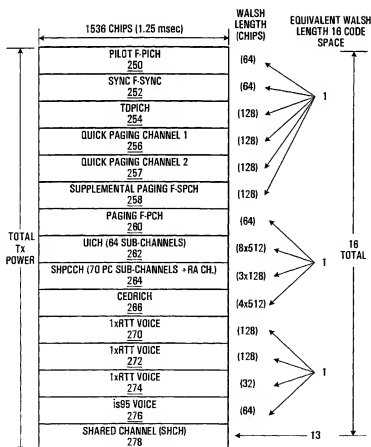
(57) Abstract: A forward link design is provided employing CDMA (code division multiple access) technologies in which time division multiplexing is employed between data and control information on the forward link to service multiple users per slot. Another forward link design employing CDMA (code division multiple access) technologies is provided in which code division multiplexing between data and control information is employed on the forward link to service multiple users per slot, which is preferably backwards compatible with legacy standards such as IS2000A. A reverse link design is also provided.

WO 02/35735 A2

SHARED CHANNEL STRUCTURE, ARQ SYSTEMS AND METHODS

FIELD OF THE INVENTION

This invention relates to CDMA systems which provide both data and voice functionality.

BACKGROUND OF THE INVENTION

Code Division Multiple Access (CDMA) is a cellular technology originally standardized as IS-95, which competes with GSM technology for dominance in the cellular world. CDMA employs spread-spectrum technology which increases the capacity of cellular systems. CDMA was adopted by the Telecommunications Industry Association (TIA) in 1993. Different variations now exist, with the original CDMA now known as cdmaOne. For example, there is now cdma2000 1xRTT and its variants like 1xEV-DO and 1xEV-DV and 3xRTT Multi-Carrier (MC 3x). These basically refer to variants of usage of a 1.25 MHz carrier channel. For example, MC 3x uses a 3.75 MHz carrier channel. By May 2001, there were 35 million subscribers on cdmaOne systems worldwide.

Third Generation efforts under ITU's IMT-2000 initiative have been motivated in large part by a need to increase the supported data rates over wireless channels. The demand for high rates has not been met by second generation systems since these systems have been defined and designed for only voice and low-rate data. Higher data rates require more bandwidth on the radio channel for transmission.

The cdma2000 standard is a 3rd Generation (3G) solution based on the original IS-95 standard. Unlike some

other 3G standards, cdma2000 is an evolution of an existing
wireless standard. The cdma2000 standard supports 3G
services as defined by the International Telecommunications
Union (ITU) for IMT-2000. 3G networks will deliver
5   wireless services with better performance, greater cost-
effectiveness and significantly more content. Essentially,
the goal is access to any service, anywhere, anytime from
one wireless terminal i.e. true converged, mobile services.

        Worldwide resources are currently being devoted
10 to roll out third-generation CDMA technology. The cdma2000
standard is one mode of the radio access "family" of air
interfaces agreed upon by the Operators Harmonization Group
for promoting and facilitating convergence of third
generation (3G) networks. In other words, the cdma2000
15 standard is one solution for wireless operators who want to
take advantage of new market dynamics created by mobility
and the Internet. The cdma2000 standard is both an air
interface and a core network solution for delivering the
services that customers are demanding today.

20   The goal of the cdma2000 standard was to mitigate
risks, protect investments and deliver significant
performance boosts to operators as they evolve their
networks to offer 3G services. Networks based on cdma2000
are backward compatible to cdmaOne (IS-95) deployments,
25 protecting operator investments in cdmaOne networks and
providing simple and cost-effective migration paths to the
next generation. In addition, cdma2000 networks offer
voice quality and voice capacity improvements, and support
for high speed and multimedia data services.

The first phase of cdma2000 - variously known as 1xRTT, 3G1X, or just plain 1X - offers approximately twice the voice capacity of cdmaOne, average data rates of 144 kbps, backward compatibility with cdmaOne networks, and many other performance improvements. The cdma2000 1xRTT standard can be implemented in existing spectrum or in new spectrum allocations. A cdma2000 1xRTT network will also introduce simultaneous voice and data services, low latency data support and other performance improvements. The backward compatibility with cdmaOne provided by cdma2000 further ensures investment protection.

However, the cdma2000 standard is evolving to continually support new services in a standard 1.25 MHz carrier. In this regard, the evolution of CDMA2000 beyond 1xRTT is now termed CDMA2000 1xEV or 1xEV for short. 1xEV is further divided into two stages: 1xEV-DO and 1xEV-DV. 1xEV-DO stands for 1X Evolution Data Only. 1xEV-DV stands for 1X Evolution Data and Voice. Both 1xEV evolution steps provide for advanced services in cdma2000 using a standard 1.25 MHz carrier. The evolution of cdma2000 will, therefore, continue to be backwards compatible with today's networks and forward compatible with each evolution option.

The 1xEV-DO standard is expected to be available for cdma2000 operators sometime during 2002, and will provide for even higher data rates on 1X systems. Specifically, 1xEV-DO specifies a separate carrier for data, and this carrier will be able to hand-off to a 1X carrier if simultaneous voice and data services are needed. By allocating a separate carrier for data, operators will

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be able to deliver peak data transmission rates in excess
of 2 Mbps to their customers.

It is envisioned that 1xEV-DV solutions will be
available approximately one and a half to two years after
5   1xEV-DO. A goal of 1xEV-DV is to bring data and voice
services for cdma2000 back into one carrier. That is, a
1xEV-DV carrier should provide not only high speed data and
voice simultaneously, but should also be capable of
delivering real-time packet services.

10   In summary, then, the cdma2000 1xRTT standard is
optimized for voice and provides basic packet data services
up to 163.2kbps. This standard is currently being
commercialized and will be in the market very soon if not
already. The cdma2000 1xEV-DO standard is optimized for
15   data only and provides efficient data service up to 2 Mbps.
This standard is to be deployed after cdma2000 1xRTT.
Finally, a proposed cdma2000 1xEV-DV standard is to be
optimized for both data and voice. Providing simultaneous
voice and data services, the goal of such a standard is to
20   provide more spectrum efficiency. Therefore, in terms of
the evolution path of the cdma2000 standards for wireless
high-speed data transmission, the cdma2000 1xRTT standard
is currently progressing towards a cdma2000 1xEV-DO
standard which is, in turn, progressing towards an
25   optimized cdma2000 1xEV-DV standard.

In examining the migration path from the 1xRTT
standard to 1xEV-DO, those skilled in the art will
appreciate that High Data Rate (HDR) technology served as
the base technology for 1xEV-DO. Furthermore, the
30   incorporation of the 1xRTT reverse link in 1xEV-DO achieved

the objectives of technology reuse as well as providing a
cost-effective solution.

        In a similar manner, a graceful evolution from
1xEV-DO to 1xEV-DV will minimize re-investments and avoid
5   fragmenting the industry. In this light, 1xEV-DV should be
backward compatible to the 1xRTT family of standards and
products. In other words, customer and operator
investments in CDMA systems should be protected. There
should be maximum reuse whenever possible and the 1xEV-DV
10 standard should also consider possible future evolutions
such as packet voice.

        In addition to the above, any 1xEV-DV proposal
should meet the CDMA Development Group (CDG) and Operator's
requirements. Specifically, 1xEV-DV should support
15 services with various QoS attributes, simultaneous voice
and data on the same carrier, voice capacity enhancement,
more spectrum efficiency in packet data transmission and
scalability to 3X mode operations.

        1xEV-DO increases data capacity but does not
20 allow for voice on the same carrier and therefore does not
change the voice capacity of the cdma2000 family. Voice
traffic must continue to use 1xRTT. As of Oct 22, 2001
1xEV-DV proposals have integrated voice and data but voice
is handled in the same fashion as 1xRTT thus the voice
25 capacity is unchanged.

SUMMARY OF THE INVENTION

        A first broad aspect of the invention provides a
method of transmitting over a forward link in a CDMA (code
division multiple access) communications system. The

method involves transmitting forward link frames, each
frame comprising a plurality of slots; for each slot,
transmitting a forward shared channel, the forward shared
channel being adapted to have up to a predetermined maximum
5   number of Walsh covers, and the forward shared channel
being scheduled slot-wise to carry in some slots content
for a single high-rate data user, in some slots content for
a plurality of voice users (a voice user being voice or
low-rate data); and transmitting a user identification
10 channel adapted to allow users to determine which slots
contain their content.

        Preferably, the forward shared channel is further
adapted to have scheduled in some slots content for a
plurality of voice users and a single high-rate data users.

15   In some embodiments, the user identification
channel is transmitted in parallel with the shared channel
using a different code space.

        Preferably, during each slot the forward shared
channel is scheduled over a number of Walsh covers equal to
20 the predetermined maximum number of Walsh covers minus a
number of Walsh covers necessary to accommodate legacy
users being serviced during the slot.

        The Walsh covers in some embodiments are 16-ary
Walsh covers and in a given slot, one or more of the 16-ary
25 Walsh covers is further sub-divided for the plurality of
voice users, with all remaining 16-ary Walsh covers of the
forward shared channel being assigned to a shared data
channel which is made available to a single high-rate data
user at a time.

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Preferably, each slot has a 1.25 ms slot duration, with the shared data channel content for a given user may occupy multiple contiguous slots.

Other embodiments of the invention are defined in the appended claims 1 to 96.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described in further detail by way of example with reference to the attached drawings in which:

Figure 1A is a network schematic for a first embodiment of the invention;

Figure 1B is an example forward channel structure for use in the forward link of Figure 1A;

Figure 1C is an example forward voice traffic channel structure for use with the forward channel structure of Figure 1B;

Figure 1D is an example forward data traffic channel structure for use with the forward channel structure of Figure 1B;

Figure 1E is an example preamble channel structure for use with the forward channel structure of Figure 1B;

Figure 1F is an example power control and reverse activity channel structure for use with the forward channel structure of Figure 1B;

Figure 1G is an example forward pilot channel structure for use with the forward channel structure of Figure 1B;

Figure 2 is a first example of a forward link slot structure provided by an embodiment of the invention;

Figure 3 illustrates an example of how content might be scheduled using the slot structure of Figure 2;

Figure 4 is a second example of a forward link slot structure provided by an embodiment of the invention;

Figure 5A is an example set of physical layer parameters for data on the forward link;

Figure 5B is an example set of physical layer parameters for voice on the forward link for users having a high channel estimate;

Figure 5C is an example set of physical layer parameters for voice on the forward link for users having a medium channel estimate;

Figure 5D is an example set of physical layer parameters for voice on the forward link for users having a low channel estimate;

Figure 6 is a channel summary for another CDMA forward link structure provided by an embodiment of the invention;

Figure 7 is a slot structure of a forward link structure in which there are no legacy users;

Figure 8 is a slot structure of a forward link structure in which there are legacy users;

Figure 9 illustrates an example set of Walsh separation codes for the forward link structures of Figures 7 and 8;

Figure 10 is a block diagram of an example forward shared channel structure for data and full rate voice;

Figure 11 is a block diagram of an example forward shared channel structure for non-full rate voice;

Figure 12 is an example set of forward link shared channel voice parameters;

Figures 13 and 14 are example sets of forward link shared channel data parameters;

Figure 15 is a block diagram of an example user identification channel structure;

Figure 16 is a block diagram of an example supplementary paging channel structure;

Figure 17A is a channel summary for CDMA reverse link structure provided by an embodiment of the invention;

Figure 17B is a block diagram of an example reverse CHESS channel structure;

Figure 18 is a block diagram of an example reverse data ARQ channel structure;

Figure 19 shows an example structure for the reverse pilot channel;

Figure 20 is a reverse link timing diagram;

Figure 21A is a block diagram showing reverse channel I and Q mapping;

Figure 21B is a block diagram of the reverse advanced access/common control channel;

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Figure 21C is a block diagram of the reverse traffic/dedicated control channels;

Figure 22 is an example lower rate set of reverse supplementary channel coding and modulation parameters; and

5   Figure 23 is an example higher rate set of reverse supplementary channel coding and modulation parameters.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1A shows a system schematic of an example
10   wireless system in which various embodiment of the invention may be employed. A base station (BS) 160 is shown having three coverage area sectors 162,164,166. The base station 160 forms part of a larger wireless access network (not shown). Different numbers of sectors may be
15   employed. By way of example, shown are two wireless terminals (WT) 168,170 in sector 162, although a sector may serve more than two wireless terminals. There is a shared forward link generally indicated by 172 used for transmissions from the base station 160 to wireless
20   terminals 168,170. Each wireless terminal also has a respective dedicated reverse link 174, 176. Both the forward link 172 and the reverse links 174,176 employ CDMA fundamentals.

A first embodiment of the invention provides a
25   forward link design employing CDMA (code division multiple access) technologies in which time division multiplexing is employed between data and control information on the forward link to service multiple users per slot. The first embodiment will be described with reference to Figures 1 to

5. Preferably, this design may be employed as a forward link portion of a 1XEV-DV solution. Another embodiment of the invention provides a forward link design employing CDMA (code division multiple access) technologies in which code
5 division multiplexing between data and control information is employed on the forward link to service multiple users per slot, which is preferably backwards compatible with legacy standards such as IS2000A. This embodiment will be described below with reference to Figures 6 to 16.
10 Preferably, this design may be employed as a forward link portion of a 1XEV-DV solution. Either of the forward link designs may be used in combination with a reverse link design provided by another embodiment of the invention which is preferably also suitable as an 1XEV-DV reverse
15 link solution. The reverse link is described in detail below with reference to Figures 17 to 23. The reverse link design is preferably similar to that now standardized in 1xRTT for example but with some refinements. This allows for a significant reuse of existing hardware and software,
20 while at the same time providing excellent data performance.

          Preferably, for all embodiments, a 20 ms physical layer frame length is used for both the reverse link and the forward link. This is consistent with 1xRTT.
25 Advantageously, this frame size would allow a tri-mode modem capable of supporting IS-95, IXRTT and 1XEV-DV. Also, in the discussion which follows, where the terms "voice" or "voice user" are used, this is intended to refer to any low rate users, namely users requiring the
30 transmission of voice data per se or to users having a data

rate equivalent to the data rate required for voice information, i.e. data users requiring a relatively low data rate.

An objective of wireless access network Radio Link Protocol (RLP) ARQ schemes is to provide improved radio link quality by implementing a retransmission mechanism for all the services and applications. These embodiments of the invention provides a new ARQ mechanism for voice services in packet wireless communication systems.

There are two types of the services which may be provided. One type of service provides for delay-sensitive services, such as voice service. The other type of service provides for non-delay-sensitive service, such as data services.

For the voice services, as will be detailed below, a base station may send signals to multiple wireless terminals in one slot, each wireless terminal receiving a packet during the slot. In response to this, multiple wireless terminals will send an ARQ signal back to the base station to indicate if they received the packets correctly or not. For high-rate data services, a single user will receive data during a given slot. Two methods of achieving this are provided.

Forward Link – Time Division Multiplexed Control Implementation

Details of a first implementation of forward link 172 of Figure 1 will now be provided with reference to Figures 1 to 5. The new forward link design allows for the

efficient use of resources through the use of multiple-user forward link slots. The forward link employs a preamble that allows multi-user packets on the forward link. This results in efficient allocation of forward link slots for

5   voice and data service for multiple users.

The forward link is time multiplexed, with 20 ms frames consisting of 16 slots with 1.25 ms per slot. Each slot contains 1536 chips. Transmission starts from one of the 16 slot boundaries. As will be described in detail

10 below, each slot will support multiple users.

The forward link time-multiplexes a forward pilot channel, a forward MAC channel, and forward traffic channel(s).

The forward pilot channel is transmitted by each

15 sector in each half slot on the forward channel. Each pilot channel transmission consists of unmodulated BPSK transmitted as 96 chip bursts every half slot at full sector power.

The pilot channel is used for acquisition,

20 synchronization, demodulation, decoding and C/I estimation by all wireless terminals in the coverage area. By transmitting the pilot burst wise in this fashion, a sufficiently accurate C/I estimation can be obtained for data rate control generation and adaptive modulation and

25 coding. Pilot bursts from all of the sectors are transmitted at the same time to facilitate C/I estimation.

Referring to Figure 2, shown is where in the slot the pilot bursts are transmitted for two modes, namely an active mode during which forward link data is being

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transmitted, generally indicated by 100, and an idle mode
during which forward link data is not being transmitted,
generally indicated by 102.

5   In active mode 100, a slot on the forward link
(1.25 ms, 1536 chips) comprises a first 304 chip data
period 104, a first 32 chip MAC channel slot 106, a 96 chip
pilot burst 108, a second 32 chip MAC channel slot 110,
second and third 304 chip data periods 112,114, a third 32
chip MAC channel slot 116, a second 96 chip pilot burst
10   118, a fourth 32 chip MAC channel slot 120, and a fourth
304 chip data period 122. In the inactive mode 102, the
MAC channel slots 106,110,116,120 and pilot bursts 108,118
are transmitted at the same time during the slot as was the
case for the active mode, with the no data transmission
15   during the data periods.

The forward MAC channel carries a reverse power
control (RPC) channel and a reverse activity (RA) channel.

The forward traffic channel is provided over the
four data periods 104,112,114,122, and is used to provide
20   for different services with various QoS attributes, such as
real time data, non-real time data, etc. In some slots,
one or more of these data periods 104,112,114,122 are used
to transmit a preamble which identifies which users are
being scheduled during the slot.

25   Referring again to Figure 2, the data periods
104,112,114,122 are used for a time division multiplexed
forward traffic channel, the time division multiplexing
occurring between data transmission, and pilot and MAC
channel slot transmission. Advantageously, this allows a
30   higher number of users per slot with modest rate

requirements, or a modest number of high-rate voice and data users.

During the data periods 104,112,114,122, a number of CDMA Walsh covers are used to transmit forward traffic channels. Preferably, 16 16-ary Walsh covers are used. The Walsh covers are allocatable on a per slot basis such that a single slot is adapted to serve multiple low data rate or voice users so as to provide efficiency and flexibility, and up to one high data rate user.

Each slot is either a multi-user slot, or a single high-rate user slot. For a single user slot, all 16 Walsh covers are used to transmit data to the single high-rate user. In a multi-user slot, the 16 Walsh covers are allocated between up to 16 users, with one, two or four Walsh covers per user.

Each multi-user slot has a preamble which identifies the users who are being scheduled during the slot. Single user packets may be transmitted over multiple slots, and the first of such multiple slots contains a preamble identifying the data user and transmission parameters for the data packet.

The base station schedules data packets onto the forward traffic channel based on channel estimates fed back over the CHESS channel received from wireless terminals on the reverse link, QoS requirements and traffic load at the base station. The base station must schedule at least one voice frame onto the forward traffic channel for each simultaneous voice and data user within one 20 ms frame. The actual rate for a single user slot is specified by an EDRI (explicit data rate indicator).

Figure 3 illustrates an example slot scheduling breakdown for a multi-user slot 960 and a single user transmission 962 composed of two slots 964,966. All three slots 960,964,966 have the pair of respective pilot

5   periods, and four respective MAC channel slots. Multi-user slot 960 has a multi-user preamble 968 which in this example identifies (through user index construct, described below) four voice users each occupying 4 Walsh codes. The transmissions for the four voice users are indicated as V1,

10   V2, V3 and V4. For the single user transmission, the first slot 964 contains a preamble 970 which identifies (through the group ID construct) the data user. The entire traffic capacity of the slot 964 and the following slot 966 is dedicated to the single user as indicated by D1 in both

15   slots.

It is to be understood that other field sizes may alternatively be employed for the MAC channel slots, pilot and data periods. Another example is shown in Figure 4 for both active and idle modes where in a 1536 chip slot, there

20   are be two 348 chip data periods 140,144, two 72 chip pilot bursts 142,150, two 64 chip MAC channel slots 148,152, and two 284 chip data periods 146,154.

The forward channel structure is shown in Figure 1B. The forward traffic or control channel inputs C,D, the

25   preamble and ERDI inputs E,F, the power control and RA channel inputs G,H and the pilot channel inputs K,L are input to TDM (time division multiplexing) block 800 which performs time division multiplexing as shown in Figure 2 for example. Quadrature spreading is performed at block

30   802. I and Q outputs are baseband filtered 804,806,

modulated at 810,812 and then summed together at 814 to produce a forward modulated waveform.

The forward voice traffic channel structure is shown in Figure 1C. A voice user may be assigned more than

5   one Walsh cover, and preferably one, two or four Walsh covers. A voice user input is channel encoded 830, with an 8K or 13K encoder for example. Then scrambling, sequence repetition and/or symbol puncturing is performed at 832. Next, QPSK or 16 QAM modulation is performed 834. Walsh

10   cover is applied 836 and Walsh channel gain applied 838. Finally, the outputs thus produced for all the voice users are summed with Walsh Chip level summer 840. Outputs C and D are inputs to the forward channel structure of Figure 1B.

The forward single user data traffic channel

15   structure is shown in Figure 1D. Forward data traffic channel physical layer packets are encoded with R=1/3 or 1/5 rate encoder 860. A scrambler 862 sequence is added at 863. Then channel interleaving is employed 864 and modulation is performed by QPSK/8PSK or 16 QAM modulator

20   866. Symbol repetition and/or symbol puncturing is performed at 868. Symbol demultiplexing 16 to 1 occurs at 870. Then the appropriate Walsh cover is applied for each of the sixteen channels at 872, Walsh channel gain applied at 873, and Walsh chip level summing occurs at 874. Outputs

25   C and D are inputs to the forward channel structure of Figure 1B.

The preamble channel structure is shown in Figure 1E. The preamble initially consists of all 0's. This is signal mapped at 880. Then, a 32 symbol bi-orthogonal

30   cover with user index/Group ID i is applied at 882.

Sequence repetition is performed at 884, and a preamble
gain applied at 886. For the EDRI, 8-ary orthogonal
modulation is applied at 888, signal mapping occurs at 890,
sequence repetition occurs at 892, and an EDRI channel gain
5   applied at 894. Outputs E and F are inputs to the forward
channel structure of Figure 1B. The EDRI indicates the
coding and modulation employed for the single high-rate
user.

There are 32 Walsh x 2(plus,minus) possible bi-
10 orthogonal codes which may be applied to the preamble
structure above, thereby allowing the identification of 64
different user index/Group ID.

The preamble channel structure used in multi-user
slots is shown in Figure 1E, but no EDRI is required.

15   Each data user has a single Group ID for their
data service (this being analogous to user index I), and
this is transmitted during the preamble of a single user
slot as indicated above in the discussion of Figure 1B.
Each voice user has three Group IDs, one GID1 for use when
20 its voice is transmitted using one 16-ary Walsh cover, one
GID2 for use when its voice is transmitted using two 16-ary
Walsh covers, and one GID4 for use when its voice is
transmitted using four 16-ary Walsh covers. Each user has
Walsh covers assigned to it for each of the its three Group
25 IDs, i.e. for GID1 the user is assigned one Walsh cover,
for GID2 the user is assigned two Walsh covers, and for
GID4 the user is assigned four Walsh covers. Multiple
users may be assigned the same GIDs. When a given GID1 is
transmitted, then all voice users having been assigned GID1
30 will know to expect a voice packet on the single Walsh

cover associated with GID1 Similarly, when a given GID2 is
transmitted, then all voice users having been assigned GID2
will know to expect a voice packet on the two Walsh covers
associated with GID2, and when a given GID4 is transmitted,

5   then all voice users having been assigned GID4 will know to
expect a voice packet on the four Walsh covers associated
with GID4. The preamble functions as a user identification
channel, allowing users to determine whether a given slot
contains any content for them.

10   The structure of the MAC channel slots
106,110,116,120 is designed to facilitate this denser and
more flexible packing of users down to the sub-slot level.
The structure of the MAC channel which is used to carry
reverse power control commands and reverse activity

15   commands is shown at Figure 1F. RPC bits for user ID i are
signal mapped 900. Then RPC Walsh channel gain is applied
at 902. A 64-ary Walsh cover is applied at 904. RA bits,
1 per 8xRABLength slots (100/RABLength bps) are input to
bit repetition block 908 with repetition factor equal to

20   RABLength. Then, signal point mapping occurs at 910 and an
RA channel gain is applied at 912. A 64-ary Walsh cover is
applied at 914. The outputs of 904 and 914 are summed with
Walsh chip level summer 906 which has an output which is
sequence repeated 916. Outputs G and H are inputs to the

25   forward channel structure of Figure 1B. The MAC channel
provides one PC bit per slot for up to 63 users and one RA
bit per slot. A first state of the RA bit indicates to all
users transmitting on the reverse link that things are fine
as they stand, and a second state of the RA bit indicates

30   to all users transmitting on the reverse link that there is

too much activity on the reverse link and that data rates
should be lowered.

     Finally, the pilot channel structure is shown in
Figure 1G. Here, the pilot channel bits which consist of
5 all 0's, are signal mapped at 930 and then the Walsh cover
0 is applied at 932. Outputs K and L are inputs to the
forward channel structure of Figure 1B.

     The forward link physical layer parameters for
data are shown in Figure 5A. Data packets can be from 1 to
10 16 slots in length. the preamble for the different
possibilities also varies from being as small as 128 chips
to as large as 1024 chips. When the preamble is longer,
the user index/group ID for the data user is repeated.

     The forward link physical layer parameters for
15 voice are shown in Figure 5B, 5C and 5D for users having
high, medium and low channel estimates respectively. In
Figure 5B, the parameters are used when there are 16 voice
users, with one Walsh code per user. Figure 5C shows the
parameters used when there are eight users with two Walsh
20 codes per user. Figure 5D shows the parameters used when
there are four users with four Walsh codes per user.

Forward Link – Code Division Multiplexed Control
Implementation

     Another embodiment of the invention provides a
25 forward link design in which control is multiplexed with
data using code multiplexing. This embodiment will now be
described with reference to Figures 6 to 16. The new
channel breakdown for the forward link is shown in Figure
6. The forward channels include:

Forward Pilot Channel (F-PICH) 250;

Forward Sync Channel (F-SYCH) 252;

TDPICH channel 254;

Supplemental Paging Channel (F-SPCH) 258;

5   Quick Paging Channel 1 256;

Quick Paging Channel 2 257;

Forward Paging Channel (F-PCH) 260;

User identification channel (UICH) 262;

Forward Shared Power Control Channel (F-SHPCCH);

10   Common Explicit Data Rate Indication Channel (CEDRICH) 266;
and

Shared Channel (SHCH) 268.

        Preferably, the pilot channel 250, sync channel
252, TDPICH channel 254, quick paging channels 256,257, and
15   paging channel 260 have the same channel structure as the
corresponding channels as defined by IS2000A. Furthermore,
preferably, the shared power control channel 264 has a
similar structure to the CPCCH (common power control
channel) provided by IS2000A, with differences noted below.
20   Each of the channels which are not based on IS2000A are
described in detail below.

Forward Link Operation.

        The forward link uses code division multiplexing
within time division multiplexing on a new shared channel
25   (SHCH). The SHCH allows flexible slot scheduling and slots
with multiple voice users and up to one data user. Forward
link transmission is organized as 20 ms frames. Each frame

consists of sixteen 1.25ms slots. Each slot contains 1536
chips.

        The slot structure of the forward link depends
upon whether service is to be provided to legacy IS95/1xRTT
5 users. A forward slot/code structure is shown in Figure 7
for the case where it is assumed there are no IS95/1xRTT
users. Effectively, there are 16 Walsh length 16 code
space subchannels.

        The slot structure contains the following
10 channels: Forward Pilot Channel (F-PICH) 250 having a Walsh
length of 64 chips, Forward Synch Channel (F-SYCH) 252
having a Walsh length of 64 chips, the TDPICH channel 254
having a Walsh length of 128 chips, the supplemental paging
channel F-SPCH 258 having a Walsh length of 128 chips. The
15 slot structure has quick paging channels 256,257 each
having a Walsh length of 128. Channels 250,252,254,256,257
and 258 collectively effectively occupy one Walsh 16 code
space. The slot structure also has Forward Paging Channel
(F-PCH) 260 having a Walsh length of 64 chips, and eight
20 user identification channel (UICH) 262 each having 8
subchannels and Walsh code of length 512 chips, for a total
of 64 UICH subchannels. If additional user identification
channel capacity is required, then additional Walsh codes
can be assigned code space permitting. Space may also be
25 taken from the shared channel if necessary. The slot
structure further includes three Forward Shared Power
Control Channels (F-SHPCCH) 264 each having 24 subchannels
and a Walsh length of 128 chips, giving a total of 72 power
control bits per slot capacity since for each of the three
30 code channels, 24 power control bits can be time division

multiplexed and transmitted. Preferably, two of the power
control bits are used by the Reverse Activity (RA) channel,
which are used to broadcast reverse activity commands and
can be used for reverse link rate control. It is noted

5   that six bits of the FSPCCH are preferably used for the
advanced access channel described in applicant's copending
application. If additional power control subchannels are
required, then extra code space may be allocated for this
purpose. The slot structure also has a common explicit

10 data rate indication channel (CEDRICH) 266 which has four
Walsh codes of length 512 chips. Channels 260,262,264 and
266 collectively effectively occupy one Walsh 16 code
space. Finally, the shared channel (SHCH) 14 which
occupies 14 Walsh 16 code spaces. A detailed example

15 breakdown of the Walsh separation is provided in the table
of Figure 9.

         In the event there are IS95/1xRTT (legacy) users
which need to be supported, the slot structure of Figure 7
easily adapts to allow this. A subset of the capacity of

20 the shared channel 268 can be used for these legacy users.
An example is shown in Figure 8 for the case where it is
assumed there are IS95/1xRTT users. The slot structure is
the same as that of Figure 7 down until the shared channel.
The slot structure of Figure 8 has two 1xRTT voice channels

25 270,272 each having a Walsh length of 128, one 1xRTT data
channel 272 having a Walsh length of 32, and one IS95 voice
channel 276 having a Walsh length of 64, these legacy
channels collectively occupying one Walsh 16 code space
which was taken from the capacity formerly allocated to the

30 shared channel leaving a smaller Shared Channel (SHCH) 278

24

is which occupies 13 Walsh code spaces rather than 14 as
was the case for the Shared Channel of Figure 7. Depending
on the number of legacy users at a given time, the size of
the shared channel 278 can shrink, potentially down to
5   zero, or grow back to the maximum 14 Walsh code spaces
nominally allocated.

Forward link Shared Channel (SHCH)

        The shared channel 268 is a very flexible
channel. The shared channel, in this example, may have up
10   to 14 16-ary Walsh codes.

        In one embodiment, each SHCH 1.25 ms slot is
assignable on a TDM basis for a combination of voice users
plus a single data user, or for a single high-rate data
user.

15   The assumption being made is that the high-rate
data user does not require real time traffic delivery. For
a given user, it is acceptable to wait until enough
information has built up to fill an entire slot for the
user and/or to wait until the channel to the given user is
20   good.

        In one embodiment, the SHCH has a fixed
bandwidth. In another embodiment, the SHCH has a bandwidth
equal to a maximum bandwidth minus a bandwidth required to
service legacy voice and low-rate data users. More
25   specifically, in this embodiment space on the shared
channel 268 can be taken as needed to support legacy voice
and data channels, thereby reducing the size of the shared
channel 268.

25

Nominally, the shared channel is scheduled on a 1.25 ms basis. However, for high rate data users, longer scheduling periods of 1.25, 2.5 and 5 msec may be allowed.

A data-only SHCH slot has all 14 available 16-ary
5   Walsh codes allocated to a single user's data. Alternatively, if some of the SHCH 16-ary Walsh codes have been allocated for legacy traffic, then a data-only SHCH preferably uses all the remaining SHCH 16-ary Walsh codes.

A hybrid SHCH slot has the 14 available 16-ary
10 Walsh codes (or whatever number are available after servicing legacy users) split between one or more voice users and up to one data user. Voice users may take up all of the SHCH 16-ary Walsh codes.

A number of different modulation and coding
15 schemes are preferably supported for voice users as summarized in Figure 12 including full, half, quarter and eighth rate. Full rate voice uses Turbo coding and can use either one or two SHCH 16-ary Walsh codes depending upon the channel estimates (CHE) fed back to the base station
20 and other factors. Half, quarter and eighth rate voice uses convolutional coding and uses only one SHCH 16-ary Walsh code. The wireless terminal must blindly distinguish between the five possibilities based on getting the correct CRC. Per voice user gain is also adjusted based on the
25 CHE.

A number of different modulation and coding schemes are also supported for the high rate data user as summarized in the tables of Figures 13 and 14. Other rates may also be supported. Data users adapt modulation and
30 coding based on the Channel Estimate (CHE) every 1.25 msec.

Because the size of the portion of the shared channel which may be dedicated to a high-rate user varies as a function of how many voice and legacy users are also scheduled in the same slot, many different effective data rates are

5 required.

A preferred forward shared channel structure for a single high-rate data user which is the same as that for a single full rate voice user is shown in Figure 10 where it is assumed that the user has N Walsh codes. The single

10 high-rate data user may have up to all N=14 Walsh codes, while the voice user will have either one or two Walsh codes. Physical layer packets are encoded with 1/5 rate Turbo encoder 402 and then pass through channel interleaver 404 and preferably processed by SPIRSS block 405 and then

15 modulated with modulator 406 (which may be QPSK, 8-PSK or 16-QAM depending upon modulation type). The symbols thus produced are 1 to N demuxed 416 and the appropriate long code is added, the long code being produced by applying the long code mask to a long code generator 410 followed by

20 decimator 412. Walsh channel gain is applied 420, and the appropriate N Walsh covers 418 are applied. Finally Walsh chip level summing 422 occurs.

In one embodiment of the invention, the even second timing referenced to UTC (Universal Coordinated

25 Time) is used to select the portion of the 1/5 rate Turbo coded binary symbols to be transmitted over a given slot. Before describing this embodiment in detail, the following notations are defined:

N is the user payload packet size in number of

30 symbols;

M is the coded packet size, which is the packed size (in number of symbols) after 1/5 rate Turbo coding, M=5N;

L is the actual transmitted packet size in number
5   of symbols. The effective coding rate is N/L.

In both the access network and the wireless terminal, there is a count referenced to the even second. At the start of each even second, the count is cleared to zero. Then for each four slots (i.e. every 5 ms), the
10 count is increased by one. Since there are 1600 slots in one even second period, the count value can go from 0 to 399. For example, if the starting position of the even second is aligned with the starting position of slot 0 of the current frame, the count value at slot 0, 1, 2, and 3
15 of the current frame would be 0. The count value at slot 4, 5, 6, and 7 of the current frame would be 1. The count value at slot 8, 9, 10, and 11 of the current frame would be 2. The count value at slot 12, 13, 14, and 15 of the current frame would be 3. The count value at slot 0, 1, 2,
20 and 3 of the next frame would be 3 and so on.

The Turbo coded packet can be viewed as a periodic signal with the period equal to M. The actual transmitted packet will be selected from the periodic coded packet based on the count value at the current slot on
25 which it will be scheduled on. If the packet to be transmitted requires more than one slot, it will be selected from the periodic coded packet based on the count value at the first slot.

Suppose that the count value at the current slot is k. The starting position of the actual transmitted packet is calculated from

$$i1 = 1 + (kL) \bmod M.$$

5 The ending position of the actual transmitted packet is calculated from

$$i2 = i1 + L-1$$

When the wireless terminal receives the packet, it can derive the packet size information (N, M, L) from 10 the CEDRIC channel (described in detail below). From the count value at the slot the packet is received (or at the first slot the packet is received if the received packet contains multiple slots), it knows which portion of the 1/5 rate Turbo coded data packet the received packet belongs to 15 and decodes the packet in a proper way. If the decoded result does not pass CRC, the wireless terminal will check if the previous received packet is decoded correct or not. If the previous received packet is wrong, the current received packet will be used for soft combining and/or 20 incremental redundancy with the previous received packet. If the previous received packet is correct or the joint decoded result is wrong, a NAK signal is sent to the base station. The current received packet will be stored and may be used for soft combining and/or incremental 25 redundancy with the future received packet.

A preferred forward shared channel structure for non-full rate voice is shown in Figure 11. There is a channel structure instantiation for each non-full rate voice user. In Figure 11, two such identical channels

structure are shown 440,445. Channel structure 440 will be
described by way of example. Physical layer packets are
encoded with encoder 450 and then pass through channel
interleaver 452, and QPSK modulator 454. I and Q channels
5 thus produced then undergo sequence repetition and/or
symbol puncturing 456. The appropriate long code is added,
the long code being produced by applying the long code mask
to a long code generator 458 followed by decimator 460.
The appropriate Walsh cover 462 is applied, Walsh channel
10 gain 464 is applied, and finally Walsh chip level summing
482 occurs.

        SHCH and Hybrid SHCH slots are scheduled by the
base station, and wireless terminals are informed of
whether a given slot contains voice/data for it using the
15 User Identifier Channels (UICH).

        A user identification channel (UICH) is a forward
channel which provides a method of informing a wireless
terminal of whether a current slot of the shared data
channel contains his/her data. In a preferred embodiment,
20 eight Walsh codes of length 512 are allocated for the UICH
channel. A user's identification transmitted on this
channel consists of a three bit sub-identifier transmitted
using an I or Q component of one of the eight Walsh codes.
There are four different three bit sub-identifiers as
25 follows:

        Identifier 1: 000

        Identifier 2: 010

        Identifier 3: 110

        Identifier 4: 101

In each slot, a sub-identifier is spread by a 512-ary Walsh
code and can be transmitted on either I or Q components.
Since I and Q components can be detected independently and
eight Walsh codes are used for the UICH, there is a total
5   of 64 users (8 Walsh codes x 2 components x 4 sub-
identifiers) which can be identified uniquely by the
channel. For each slot, up to sixteen users can be
identified. The UICH channel structure is shown in Figure
15. The mapping between a given user and a UICH identifier
10 is set up each time a wireless terminal connects. Then,
the sub-identifiers to be transmitted on the I and Q
components are encoded with encoders 320,322, provided with
channel gain with channel gain elements 324,326, and then
Walsh code covered (not shown) and transmitted.

15   The above described User Identifier Channels
(UICH) indicate which user or users are scheduled in the
current slot. Up to sixteen users may be identified per
slot. A user with simultaneous Data and Voice has one UICH
for Data and one UICH for Voice. The user is informed of
20 its UICH(s) during initial signaling with the base
station.

            More generally, the sub-identifier is an N bit
identifier, and the Walsh code is one of P M-ary Walsh
codes. The user identification channel is transmitted in K
25 chip slots, and has I and Q channels, thereby providing the
2*K/(M) bit capacity, and the ability to transmit 2*K*M/N
user identifiers per slot. In the above example, M=512,
K=1536, N=3 and P=8 thereby providing the ability to
transmit 16 user identifiers per slot, and the ability to
30 uniquely identify 64 different users. In another specific

example, M=512, K=1536, N=3, P=16 thereby providing the
ability to transmit 32 user identifiers per slot, and the
ability to uniquely identify 128 different users.

        Preferably, voice users are scheduled in the
5   first half frame (i.e. in the first eight slots). An ACK
signal is sent by a wireless terminal if the wireless
terminal receives a voice packet correctly. When the
wireless terminal decodes the UICH correctly and detects
the signal by measuring its energy and the CRC of the
10 received voice packet fails, a NAK signal is sent to the
base station. Otherwise, no ACK or NAK signal will be
sent. When a NAK is received for a voice packet, the base
station will re-transmit the packet unless the voice rate
is 1/8 rate in which case the voice packet is not
15 retransmitted.

        Voice users are assigned a voice channel number
($V=0,1,2,\ldots$) which is used to calculate the one or two W16
codes on which it will receive voice information. The
supplemental paging channel SPCH broadcasts the total
20 number of 16-ary Walsh codes available (Nd) on the SHCH.
For Data only SHCH slots, Nd will be the number of codes
available to the data user. Also broadcast is the number
of 16-ary Walsh codes available for voice in hybrid SHCH
slots (Nv). In a hybrid slot, there would be Nd-Nv Walsh
25 codes for the high rate data user. The Wx116 and Wx216
codes for a particular voice user are calculated by:

$X1 = 15 - \text{mod}(V, Nv)$ and $X2 = 15 - \text{mod}(V+1, Nv)$

        Scheduling is performed on the basis of QoS
commitments, the channel estimates received from the
30 wireless terminals and sector select values. If a sector

select erasure is received corresponding to a data user then no data will be scheduled for that user. If a sector select erasure is received corresponding to a voice user then voice information will continue to be scheduled for

5   that user. Two sector select values corresponding to another valid sector must be received before the active sector stops sending voice information.

A preferred structure for the SPCH is shown in Figure 16. The Supplemental Paging Channel (SPCH)

10   broadcasts Nd and Nv as detailed above. The channel bits containing this information are convolutionally encoded with encoder 430, and interleaved with channel interleaver 432. A long code mask generated by long code mask generator 434 and decimator 436 is applied, and then

15   channel gain 438 and demux functions 440 are performed.

The Common Explicit Data Rate Indication Channel (CEDRICH) is used to indicate the coding/modulation format applied for data only use of the shared channel. Another embodiment of the invention provides this channel used to

20   determine the data rate for data transmitted on the Shared Channel. Preferably, four Walsh codes of length 512 are used for the channel.

The data rate can be determined from the number of Walsh codes used for data, the data packet size and

25   packet length. The Supplemental Paging Channel broadcasts the number of Walsh codes for the Shared Channel and the number of Walsh codes used for voice when both voice and data are transmitted in the Shared Channel in a single slot. The CEDRIC channel carries the information of packet

30   size, packet length and a slot type flag indicating whether

the slot is for one data-only user or for multiple data and
voice users. To help wireless terminals to do high order
demodulation (64-QAM or 16-QAM), a gain value may be
included in CEDRIC.

5   The CEDRIC is composed of three sub-channels.
The first one (CEDRIC_a) carries the packet length in units
of slots, and it is represented by three symbols (1536
chips after spreading) transmitted in I component of a
Walsh code in a slot. The mapping between the symbols and
10 packet length is specified in Table 2.

Table 2. The mapping between the symbols and packet length

Packet Length (slots)	Symbols
1	No energy
2	000
4	111

          The second sub-channel (CEDRIC_b) carries
information consisting of Data Packet Size and slot type
15 flag for Low Order Modulation (QPSK and 8-PSK). The third
sub-channel (CEDRIC_c) carries information consisting of
Data Packet Size and slot type flag and the gain value for
high order modulation (64-QAM or 16-QAM).

          Each sub-channel uses different Walsh codes. For
20 low order modulations, one Walsh code is assigned to carry
the packet size information. Two packet sizes will be used
if the packet is transmitted in one slot, therefore only

one bit is needed to indicate the packet size (see Table 3). One more bit (slot type flag) is needed to indicate whether the slot is for one data-only user or for multiple data and voice users (see Table 4). Four packet sizes can

5   be used when a packet is transmitted in multiple slots and two bits are needed to indicate the packet size (see Table 5). However, only data packets are transmitted in multiple slots and thus the slot type flag is not needed. In summary, for both single slot packets or multiple slot

10 packets, two bits are encoded into six symbols, which are spread by a 512-ary Walsh code and transmitted on I and Q components.

Table 3. Packet Size Indication for Single Slot Packets

Packet Size Flag	Packet Size
0	3072
1	1536

15 Table 4. Slot Type Indication for Single Slot Packets

Slot Type Flag	Slot Type
0	Data only
1	Mixed

Table 5. Packet Size Indication for Multiple Slot Packets

Packet Size	Packet

Flag	Size
00	3072
01	1536
10	768
11	384

For high order modulations, two and a half Walsh codes (half meaning the Q component of the Walsh code used for packet length) are assigned to carry the packet size

5   and the gain information. Similar to the low order modulation, a 1-bit packet size flag and a 1-bit slot type flag are used for single slot packets while a 2-bit packet size flag is used for multiple slot packets. Five bits are used to represent the gain. All seven bits are encoded

10 into fifteen symbols and are spread by 512-ary Walsh codes.

If a packet is transmitted in a single slot, the packet size, slot type flag (and gain when applicable) will be transmitted in the same slot with the data packet. If a packet is transmitted in multiple slots, the packet length

15 (number of slots) will be transmitted in the first slot. The packet size (and gain when applicable) will be transmitted in the following slots. Effectively, only one sub-channel is transmitted in one slot.

Shared Power Control Channels (SHPCCH) handle

20 reverse link PC when forward link uses SHCH. Details of a preferred implementation are provided in Applicants below-referenced copending application.

The SHPCCH is used by the reverse advanced Access
Channel (AACH). Predefined PC bits from the SHPCCH to
acknowledge and to power control wireless terminal pilots
prior to message transmission from wireless terminals
5 during access probes.

Preferably, two bits are used to send a single
reverse activity (RA) control bit repeated twice. A first
state of the RA bit indicates to all users transmitting on
the reverse link that things are fine as they stand, and a
10 second state of the RA bit indicates to all users
transmitting on the reverse link that there is too much
activity on the reverse link and that data rates should be
lowered.

NAK for Outer Loop Power Control

15   The base station adjusts the power transmitted to
users on the basis of the channel estimate information fed
back from the wireless terminals. Preferably, in another
embodiment, NAK signals fed back from wireless terminals
are used to determine a measure of frame error rate, and
20 this measure is used for outer loop power control, i.e. to
change the manner by which the channel estimates are mapped
to base station transmission power. By counting the NAK
and no ACK/NAK frames, the base station can calculate the
forward link frame error rate. This error rate can then be
25 used to make a decision in respect of outer loop power
control. No other signaling from the reverse link is
needed for this outer loop power control.

Reverse Link Operation

Details of a reverse link design provided by another embodiment of the invention used for reverse links 174,176 of Figure 1 will now be provided with reference to Figures 17 to 23. Preferably, the reverse link is the

5   1xRTT reverse link with the addition of a new channel for feeding back channel estimates and sector selections, new channels for ARQ feedback and reverse rate indication, and a modified reverse supplementary channel having the data rate indicated by the Reverse Rate Indication (RRI)

10 channel. Each 20 ms reverse link frame consists of 16 1.25 ms slots or power control groups. Code channels are used for multiplexing (fundamental, supplemental channels). A frame offset is applied to randomize the reverse link transmissions.

15 Referring now to Figure 17A, the reverse link has the following channels:

a reverse pilot channel (R-PICH) 272;

reverse MAC channels consisting of the R-CHESS (reverse channel estimate and sector select) channel 270,

20 RRI (reverse rate indicator) channel 282, reverse data ARQ (R-DARQ) channel 276, reverse voice ARQ (R-VARQ) channel 274;

reverse traffic channels which include reverse fundamental channel (R-FCH) 278 (for voice traffic) and

25 reverse supplemental channel (R-SCH) 280 (for data traffic);

reverse advanced access channel (R-AACH) 288;

reverse dedicated control channel (R-DCCH) 284; and

38

reverse common control channel (RCCCH) 286.

Each of the reverse link channels will now be
detailed in turn with reference to Figure 20 which is a
reverse link timing diagram showing how the timing of the

5 various reverse link channels relates to that of the
forward channels slots as received by a wireless terminal.
Forward link traffic is transmitted over 20 ms frames
containing 16 1.25 ms forward channel slots 190. T0 is the
frame boundary at the wireless terminal with an assumed

10 round trip delay of 0. Of course there would be a non-zero
round trip delay which would increase as a function of a
wireless terminal's distance from the base station. This
would have the effect of delaying all of the reverse link
timing with respect to the actual forward link slot timing,

15 but not with respect to the forward link slots as received
at a given wireless terminal.

Reverse Pilot Channel, RRI Channel, and VARQ Channel

The reverse link MAC is composed collectively of
the fast reverse VARQ channel 274, reverse DARQ channel

20 276, RRI channel 282 and R-CHESS channel 270 (described in
detail below). The structure of the pilot channel is
preferably the same as the 1xRTT reverse link pilot
channel. The last 384 chips of every 1.25 msec slot
contains a single bit of information. For 1xRTT this bit

25 is a power control bit. For this embodiment of the
invention this bit is instead used to communicate VARQ and
RRI. The pilot channel is used by the BS as a phase
reference, for channel estimation and for the reverse link
power control.

The reverse pilot channel 194 is the same as the
IXRTT reverse pilot channel when operating in backward
compatible mode. In backwards compatible mode, the
wireless terminal is a legacy wireless terminal. In this
5   embodiment of the invention, rather than providing another
dedicated ARQ channel for VARQ for each wireless terminal,
the power control bits (PCB) of the pilot signals in the
1xRTT reverse link structure are replaced by a reverse rate
indicator (RRI) and ARQ for voice services. When the
10   wireless terminal used the forward shared channel for the
forward link, then each pilot channel 194 slot contains
pilot, RRI, and VARQ fields as described in detail below.
The timing of the reverse pilot channel is shown in Figure
20 and is slightly different depending on whether voice
15   only indicated generally at 194, or voice and data is being
transmitted indicated generally at 202. In both cases, the
reverse pilot channel 194,202 is aligned with the forward
channel slots, so there are 16 1.25 ms slots.

The reverse link pilot channel is summarized at a
20   very high level in Figure 19. Again, this is similar to
the 1xRTT reverse pilot channel except that the power
control bits are now replaced by RRI (reverse rate
indicator) and Voice ARQ (VARQ) bits. The pilot channel
over one slot contains a pilot period 180 during which 1152
25   pilot chips are sent, and a period 182 during which the
PCB/RRI/VARQ is sent over 384 chips, PCB being sent by
legacy terminals. During an entire frame, there are 16 bit
positions available through the collective use of period
182 from 16 slots (formerly used for power control) which
30   are now used for RRI/VARQ.

40

Case 1: Voice only users

        For the voice only users, the position of the ACK
or NAK bit is not fixed. Slots 2, 6, 10 and 14 are
reserved for RRI. A single RRI bit is mapped to all 4 bit
5   positions to indicate the use of the fundamental channel
and dedicated control channel. Setting all four RRI bits
to "0" in one frame indicates that there is only
fundamental channel being transmitted. Setting all four
bits in one frame to "1" indicates that the DCCH and
10   fundamental channel are being transmitted.

        If a user's voice data is decoded correctly, the
ACK VARQ signal will be sent to the base station in all the
slots in the frame. If nothing was transmitted for the
user in a given slot, or if the user's voice data is
15   decoded incorrectly, then a NAK VARQ signal will be sent to
the base station. Preferably, a "1" is sent to indicate an
ACK, and a "0" is sent to indicate a NAK. The possible
positions of the VARQ signals are in slots
3,4,7,8,9,11,12,13 and 15 of the current frame and slots 0
20   and 1 of the next frame. For a Forward traffic channel
voice frame transmitted in slot n of the forward channel,
the corresponding ACK channel bit is transmitted in slots
n+2 and any following remaining slots in the frame and
slots 0 and 1 of the following frame.

25   An example of this can be seen in the timing
diagram of Figure 20 where it is assumed a forward voice
packet for a voice only user is sent to a given wireless
terminal during slot n 204. After slot n and slot n+1 are
received, slot n+2 containing an RRI bit 208, the VARQ is
30   included in the RRI/VARQ bit in the reverse pilot channel

194 during the following the remaining non-RRI slots of the frame, including for example slots 206,207 and during the first two slots of the next frame (not shown).

Case 2: Voice and Data users

5   The timing of the VARQ for voice plus data users is shown in Figure 20 indicated generally at 202. In this case, 14 PC bits in one frame will be used for RRI to indicate the rate being used on the reverse supplemental channel. Preferably, each RRI symbol (3 bits) is mapped to 10 a simplex code with a length of seven, repeated twice, mapped to RRI/VARQ locations 0 to 8 and 11-16. The RRI is used to indicate whether the dedicated control channel or supplemental channel or neither is active for the current frame. The three bit RRI symbol can take one of eight 15 values, one value (preferably 0) indicating that there is no DCCH and no supplemental channel, one value (preferably 1) indicating that the DCCH only is being transmitted, and remaining values 2 through 7 indicating supplemental channel only, and indicating a particular rate for the 20 supplemental channel. The rates are detailed below under the discussion of the supplemental channel with reference to Figures 22 and 23.

The VARQ signals are transmitted in fixed positions at the 9th and 10th slots 203,205. If the user's 25 data is correctly decoded, the ACK VARQ signal will be sent. Otherwise, a NAK VARQ signal will be sent to base station.

Data ARQ

For data ARQ, the data ARQ channel 196 is used by data or voice and data users which is also aligned with the forward channel slots, so there are 16 1.25 ms slots. An ACK signal is sent to the base station if the wireless
5   terminal receives a data packet correctly. When the wireless terminal detects the proper UICH and the CRC of the received data packet fails, a NAK signal is sent to the base station. When the wireless terminal does not detect the proper UICH then no ACK or NAK signal will be sent.
10 The DARQ signals for data are sent using the DARQ channel in the first half slot starting two slots after the end of the data packet is received at the wireless terminal. An example of this is shown in Figure 20 where a data packet has been transmitted on slot n, and the DARQ 197 is sent on
15 the R-DARQ channel 196 in the first half slot of slot n+3.

The structure of the reverse DARQ channel is shown in Figure 18. DARQ takes one bit per slot in first ½ slot, employs bit repetition 600, signal point mapping 602 and Walsh cover 604.

20 Reverse Link Supplemental Channel and Fundamental Channel

The reverse supplemental channel has a variable data rate from 4.8 kbps to 1228.8 kbps. The fundamental channel is supported for voice, with preferably both 1xRTT 8k and 13k vocoders being supported as well as a new 8k
25 vocoder with turbo coded full rate voice. Simultaneous voice and data can be transmitted. The variable data rates are determined by the wireless terminal in cooperation with the base station through the use of a rate set identifier broadcast by base station on the forward link, and a RRI
30 (reverse rate indicator) sent on the reverse link as

discussed in detail above. The rate set identifies either
the low rate set or the high rate set. Signaling is
transmitted on the dedicated control channel.

Figure 22 is a table of an example set of reverse
traffic channel coding and modulation parameters for a low
rate set (one supplemental channel), and Figure 23 is a
table of an example set of reverse traffic channel coding
and modulation parameters for a high rate set (two
supplemental channels). Parameters are shown for seven
different sets of parameters, each set of parameters being
distinguished by a different reverse rate indicator. Each
set of parameters has a respective data rate, encoder
packet size, overall code rate, code symbols/Packet, code
symbol rate, interleaved packet repeats, mod. Symbol rate,
data modulation, and PN chips per encoder bit. Reverse
rate indicator 0 means that there is no dedicated control
or supplemental channel content. Reverse rate indicator 1
means that only the dedicated control channel is being used
on the reverse link. Rate indicators 2 through 7 relate to
supplemental channel content. In the event a user is also
transmitting voice, this would be transmitted on the
fundamental channel.

R-CHESS Channel

A channel estimate and sector selector reporting
scheme for wireless air interface is provided by an
embodiment of the invention. In this scheme, by time
division multiplexing channel estimate and sector selector
information (compared to sending the information
simultaneously), the bit rate is reduced significantly and
reverse link capacity is improved.   A handoff mechanism is

44

also provided which uses the sector selector and channel
estimate information.

        In the new scheme, channel conditions are
reported in an objective manner.   A wireless terminal may
5   report its channel estimate to a base station to help the
base station to determine the data transmission rate.   A
wireless terminal may also monitor all the sectors it can
receive, and select the best one and report it. With the
channel estimate and sector selector information, base
10 stations can use good channel conditions more efficiently
and improve forward link throughput. In the new reporting
scheme, in every eight consecutive time slots, wireless
terminals report channel estimates in the seven consecutive
slots and report sector selector information in one slot.

15   The new channel is referred to herein as the R-
CHESS channel, standing for Reverse CHannel Estimate and
Sector Selector (R-CHESS) channel. The structure of the R-
CHESS channel is shown in Figure 17B. Three bits are used
to represent a channel estimate or a change in channel
20 estimate 300, and three bits are used to represent sector
selector symbols 302. The channel estimate or change in
the channel estimate is mapped to the three bit CHE or Δ-
CHE value depending on the coding scheme of the channel
estimate. CHE represents the current channel estimate,
25 while Δ-CHE represents the difference between the current
channel estimate and the previous channel estimate. These
are time division multiplexed 304 such that seven channel
estimates 300 (CHE and/or Δ-CHE) are reported for every one
sector selection 302. The multiplexed stream is then
30 simplex encoded with encoder 306. The codeword is then

repeated 14 times and punctured as indicated by block 308.
The result is signal point mapped 310, and then spread by
the R-CHESS channel Walsh cover 312.

          The CHE (delta CHE), SS values are transmitted at
5   a data rate of 800 values per second. The timing of the
    CHESS channel relative to other reverse link channels is
    shown in the timing diagram of Figure 20. The R-CHESS
    channel 192 is shown to have 1.25 ms slots which are one
    half slot offset from the forward channels slots. In this
10 manner, even allowing for round trip delay, a given R-CHESS
    channel slot is received at the base station in time for
    the base station to use the CHE information for the next
    forward channel slot. In the illustrated example, in a 16
    slot frame, the SS is transmitted during slots 0 (SS1) and
15 8 (SS2), CHE is transmitted during slots 1,3,5 7,9,11,13
    and 15, and Δ-CHE is transmitted during slots
    2,4,6,10,12,14. In another embodiment, a CHE value is sent
    slots 1 to 7 and 9 to 16 and no Δ-CHE is sent.

          A handoff mechanism using the R-CHESS information
20 will now be briefly described. The sector selector
    indicator is used to indicate the sector that the wireless
    terminal thinks it should be operating. The three bit
    field can indicate one of seven sectors and a null value.
    As a background process, the wireless terminal measures the
25 pilot signal strength of base station sectors, and when the
    signal strength of a sector of a base station becomes
    sufficiently strong, this is reported to the access
    network, and the sector is added to the active set for the
    wireless terminal. A sector select value is defined for
30 each sector in the active set. Similarly, when a sector's

pilot strength goes below a threshold, that sector is removed from the active set.

For reverse traffic, all sectors in the active set listen to transmissions from the wireless terminal, and

5 preferably, for each receive slot, the best of multiple signals received by multiple sectors is selected as the receive signal. This provides a soft reverse link handoff mechanism

For forward traffic, only the sector defined by

10 the sector select value transmits subject to the timing constraints below. This can change from slot to slot. Thus, forward link handoff is completely sector select driven.

Preferably, for data or data/voice users, the

15 sector select value is not allowed to change from one sector value directly to another sector value. It can only change from a sector value to the null value then to a sector value.

If the sector select value changes from a sector

20 value (for example, sector A) to the null value, the wireless terminal still reports CHE values for sector A for the some fixed number of slots, for example 7. Then the sector select can change to a different sector value and the wireless terminal starts to report CHE for the new

25 sector. For simultaneous voice and data users, both voice and data are handed off at the same time.

For voice only users, preferably the sector select is allowed to change directly from one sector value to another sector value. Also if sector select changes a

sector value, (e.g. A to B) then the wireless terminal
continues to report CHE for sector A for the remainder of
the frame, the assumption being that voice users get one
slot per frame. Then the wireless terminal begins
5 reporting values for B.

Advanced Access Channel

         A new advanced access channel described in
applicant's copending application number [attorney docket
71493-980] filed the same day as this application and
10 hereby incorporated by reference in its entirety improves
reverse link capacity.

         An example reverse channel I and Q mapping is
shown in Figure 21A. Inputs to this are the R-CHESS
channel input B, the pilot/RRI/VARQ channel input B, DARQ
15 channel input C, fundamental channel input D, and
supplemental channel or dedicated control channel or
enhanced access channel or common control channel input E.

         The structure of the advanced access channel
shown in Figure 21B. The advanced access channel or common
20 control channel bits are added to a frame quality indicator
700, turbo encoded 702, symbol repeated in symbol
repetition 704, punctured with symbol puncture 706, and
then block interleaved with block interleaver 708. Signal
point mapping is performed 710 and then the appropriate
25 Walsh cover applied 712.

         A similar structure is employed for the
fundamental channel, supplemental channel or dedicated
control channel bits as indicated at Figure 21C. The
channel bits are added to a frame quality indicator 720,

turbo encoded 722, symbol repeated in symbol repetition 724, punctured with symbol puncture 726, and then block interleaved with block interleaver 728. Signal point mapping is performed 730,732 and then the appropriate Walsh cover applied 734,736 with a different Walsh cover being applied tot he reverse supplemental or dedicated control channel than to the reverse fundamental channel.

Numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.

We claim:

1.   A method of transmitting over a forward link in a CDMA (code division multiple access) communications system, the method comprising:

5   transmitting forward link frames, each frame comprising a plurality of slots;

           for each slot, transmitting a forward shared channel, the forward shared channel being adapted to have up to a predetermined maximum number of Walsh covers, and
10 the forward shared channel being scheduled slot-wise to carry in some slots content for a single high-rate data user, in some slots content for a plurality of voice users (a voice user being voice or low-rate data);

           transmitting a user identification channel
15 adapted to allow users to determine which slots contain their content.

2.   A method according to claim 1 wherein the forward shared channel is further adapted to have scheduled in some slots content for a plurality of voice users and a single
20 high-rate data users.

3.   A method according to claim 2 wherein the user identification channel is transmitted in parallel with the shared channel using a different code space.

4.   A method according to claim 3 wherein during each
25 slot the forward shared channel is scheduled over a number of Walsh covers equal to the predetermined maximum number of Walsh covers minus a number of Walsh covers necessary to accommodate legacy users being serviced during the slot.

5.   A method according to claim 4 wherein the
predetermined maximum number of Walsh covers is 14 16-ary
Walsh covers.

6.   A method according to claim 3 wherein the Walsh
5   covers are 16-ary Walsh covers and in a given slot, one or
more of the 16-ary Walsh covers is further sub-divided for
the plurality of voice users, with all remaining 16-ary
Walsh covers of the forward shared channel being assigned
to a shared data channel which is made available to a
10 single high-rate data user at a time.

7.   A method according to claim 6 wherein each slot
has a 1.25 ms slot duration, with the shared data channel
content for a given user may occupy multiple contiguous
slots.

15 8.   A method according to claim 7 further comprising
transmitting control information in respect of the shared
data channel.

9.   A method according to claim 8 wherein the control
information in respect of the shared data channel comprises
20 an indication of a number of contiguous slots to be made
available to a given data user.

10.   A method according to claim 9 wherein the control
information comprises a data packet size and single/hybrid
slot indicator for low order modulation (QPSK and 8-PSK)
25 and data packet size, single/hybrid slot indicator, and
gain value for 64QAM and 16QAM shared channel data for high
order modulation.

11.   A method according to claim 3 wherein at least
some of the slots contain voice transmitted at full rate.

12.   A method according to claim 11 further comprising turbo encoding the voice to be transmitted at full rate and transmitting such content using one or two shared channel 16-ary Walsh codes.

5   13.   A method according to claim 3 wherein at least some of the slots contain voice content transmitted using half, quarter or eighth rate.

14.   A method according to claim 11 further comprising encoding half, quarter and eighth rate voice channels using
10   convolutional coding and transmitting such content using only one shared channel 16-ary Walsh code.

15.   A method according to claim 3 wherein frames have a 20 ms duration, with each frame consisting of sixteen 1.25 ms slots, and each slot containing 1536 chips.

15   16.   A method according to claim 3 wherein the user identification channel is used to inform a particular user whether a current slot of the shared data channel contains data for the user by transmitting a user identifier comprising a Walsh code and a sub-identifier.

20   17.   A method according to claim 16 wherein the sub-identifier is an N bit identifier, and the Walsh code is one of P M-ary Walsh codes.

18.   A method according to claim 17 wherein the user identification channel is transmitted in K chip slots, and
25   has I and Q channels, thereby providing the 2*K/(M) bit capacity, and the ability to transmit 2*K*M/N user identifiers per slot.

19.   A method according to claim 16 wherein M=512, K=1536, N=3 and P=16 thereby providing the ability to

transmit 32 user identifiers per slot, and the ability to uniquely identify 128 different users.

20.   A method according to claim 16 wherein M=512, K=1536, N=3 and P=8 thereby providing the ability to
5   transmit 16 user identifiers per slot, and the ability to uniquely identify 64 different users.

21.   A method according to claim 15 wherein a voice only user is assigned a single user identifier, and a user with voice and data is assigned one user identifier for
10   data and one user identifier for voice.

22.   A method according to claim 1 wherein for a given slot during which high-rate data is to be transmitted, data is transmitted for a high-rate data user likely to have good channel conditions during the slot.

15   23.   A method according to claim 22 further comprising performing adaptive modulation and coding for the shared data channel based on channel estimates fed back every slot.

24.   A method according to claim 3 further comprising
20   coding voice content in one of five possible ways depending upon rate and channel estimate as follows:

        full rate voice uses Turbo coding and can use either one or two shared channel 16-ary-Walsh codes with 8PSK modulation with one shared channel 16-ary Walsh code
25   or QPSK modulation with two shared channel 16-ary Walsh codes;

        half, quarter and eighth rate voice uses convolutional coding and uses only one shared channel 16-ary Walsh code.

25.   A method according to claim 1 further adapted to schedule voice users by:

giving preference to schedule voice users in a first half frame;

for each slot, looking for an ACK or NAK VARQ signal from each voice user scheduled during the slot and where possible rescheduling in the second half frame voice users from which a NAK VARQ signal is received.

26.   A method according to claim 25 wherein the VARQ signals are received on a 1xRTT-like reverse pilot channel in place of predetermined former power control bit locations.

27.   A method according to claim 26 wherein reverse rate indicator (RRI) signals are also received on the 1xRTTT-like reverse pilot channel in place of predetermined former power control bit locations.

28.   A method according to claim 27 wherein each frame has 16 slots and the positions of the VARQ and RRI signals obey the following rules:

for users with voice service only, the VARQ valid bit positions are in slots 3,4,7,8,9,11,12,13 and 15 of a current frame and slots 0 and 1 of a following frame, and slots 2, 6, 10 and 14 are reserved for the RRI;

for a user with both data and voice services, the RRI is transmitted in slots 0 to 8 and 11 to 15 and the VARQ is transmitted in slots 9 and 10.

29.   A method according to claim 28 wherein if a user's voice data in a given slot is decoded correctly, the

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ACK VARQ signal will be sent to the base station in all the
slots in the frame following the given slot and in the
first two slots of a following frame, and if no voice was
transmitted for the user in a given slot, or if the user's
5 voice data is decoded incorrectly, then a NAK VARQ signal
will be sent on all slots until a slot containing the
user's voice data is correctly decoded.

30.   A method according to claim 1 further comprising:

        processing a reverse channel for each voice user
10 scheduled during a given slot, and looking for a NAK VARQ
signal or an ACK VARQ signal in predetermined slot
positions in the reverse channel relative to the given
slot.

31.   A method according to claim 1 further comprising
15 transmitting a forward supplemental paging channel, the
forward supplemental paging channel broadcasting a number
of 16-ary Walsh codes available for shared channel slots
and a number of 16-ary Walsh codes available for voice in
hybrid shared channel slots.

20 32.   A method according to claim 1 further receiving
channel estimates from each user.

33.   A method according to claim 32 wherein for each
user, adaptive modulation and coding is performed on the
basis of the channel estimates received for that user, and
25 scheduling of users in each slot is also performed on the
basis of the channel estimates.

34.   A method according to claim 33 further comprising
receiving sector select values from each user.

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35.   A method according to claim 34 wherein the
channel estimates and sector select values are received on
a Channel Estimate and Sector Selector (R-CHESS) channel
from each user.

5   36.   A method according to claim 35 wherein the sector
select value for a given user identifies a best sector for
the given user and handoffs are performed for the given
user on the basis of the sector selector values received
from that user.

10 37.   A method according to claim 36 wherein:

          each sector selector value is used to indicate
the sector that the wireless terminal thinks it should be
operating;

          each sector select value indicates a sector
15 belonging to an active set, the active set being sectors
previously identified to have an acceptable signal
strength;

          for reverse link traffic, all sectors in the
active set listen to transmissions from the wireless
20 terminal with a best of multiple signals received by
multiple sectors being selected as the receive signal
thereby providing a soft reverse link handoff mechanism;

          for forward link traffic, only the sector defined
by the sector select value for a given user transmits to
25 the given user.

38.   A method according to claim 36 wherein for data
or data/voice users, the sector select value is not allowed
to change from one sector value directly to another sector
value, the sector select value only being allowed to change

from a sector value to the null value then to a sector value, and wherein for voice only users, the sector select value is allowed to change directly from one sector value to another sector value.

5   39.   A method according to 32 wherein sector selection precludes the changing from a sector value directly to another sector value, only allowing a change from a sector value to a null value then to another sector value.

     40.   A method according to claim 35 further
10   comprising:

          in the event a sector select erasure is received in a current active sector, if the sector select erasure is received corresponding to a data user then no data will be scheduled for that user, and the sector select erasure is
15   received corresponding to a voice user then voice content will continue to be scheduled for that user.

     41.   A method according to claim 38 further comprising:

          requiring two sector select values corresponding
20   to another valid sector to be received before the current active sector stops sending voice content.

     42.   A method according to claim 1 further comprising providing systematic predetermined incremental redundancy symbol selection for voice and data on the shared channel
25   by:

          using an even second timing referenced to UTC (Universal Coordinated Time) to select a portion of turbo coded data symbols to be sent in a given slot;

using a count value k which starts on each even second which counts from k = 0 to Kmax incrementing every (even second interval)/K;

5   calculating a starting (i1) and ending (i2) symbol positions of a actual Turbo transmitted packet are from i1 = 1 + mod(kL,M), i2 = i1 + L-1, the Turbo coded packet being viewed as a periodic signal with period M, where N is the user payload packet size in number of symbols, M is the coded packet size, which is the packed

10   size (in number of symbols) after Turbo coding, and L is the actual transmitted packet size in number of symbols resulting in an effective coding rate would be N/L;

a wireless terminal deriving packet size information, and using the count value, determining which

15   portion of the turbo coded packet the received packet belongs to.

43.   A method according to claim 3 further comprising assigning voice Walsh codes by:

assigning each voice user a voice channel number

20   V (V=0,1,2...) which is used to calculate the one or two 16-ary Walsh codes on which the voice user will receive voice information;

using a supplemental paging channel (SPCH) to broadcast the number of 16-ary Walsh codes available for

25   data only shared channel slots (Nd) and the number of 16-ary Walsh codes available for Voice in Hybrid shared channel slots (Nv);

calculating the two Walsh codes for a particular
user, Wx116 and Wx216 according to X1=15-mod(V,Nv) and
X2=15-mod(V+1,Nv).

44.   A method according to claim 1 further comprising:

transmitting a given user's voice content using a
Walsh cover previously made known to the given user.

45.   A method according to claim 30 further comprising
using negative acknowledgment (NAK) and acknowledgement
(ACK) signals for outer loop power control in voice and
data transmissions.

46.   A method according to claim 45 wherein the outer
loop power control comprises:

calculating a forward link frame error rate by
counting a number of NAK and no ACK/NAK frames; and

determining outer loop power control based upon
said forward link frame error rate.

47.   A method according to claim 1 further comprising
explicitly indicating a data rate for the shared channel
by:

providing an explicit data rate sub-channel
indicating packet size, packet length and a slot type flag
indicating whether the slot is for one data-only user or
for a data user and one or more voice users.

48.   A method according to claim 1 wherein:

each slot comprises a plurality of pre-defined
data transmission periods during which data and/or voice
can be transmitted only, has at least one pre-defined
period during which pilot data is transmitted only, and at

least one pre-defined period during which MAC channel is transmitted only.

49.   A method according to claim 48 adapted to transmit multi-user slots, each multi-user slot having a preamble containing said user identification channel, and to one slot and multi-slot single user high-rate transmissions, each first slot of a single user high-rate transmission having a preamble containing said user identification channel.

50.   A method according to claim 49 wherein the forward pilot channel is transmitted by each sector in each half slot on the forward channel as unmodulated BPSK.

51.   A method according to claim 49 wherein the pilot channel is transmitted as 96 chip bursts every half slot at full sector power.

52.   A method according to claim 49 wherein each slot comprises a first 304 chip data period, a first 32 chip MAC channel slot, a 96 chip pilot burst, a second 32 chip MAC channel slot, second and third 304 chip data periods, a third 32 chip MAC channel slot, a second 96 chip pilot burst, a fourth 32 chip MAC channel slot, and a fourth 304 chip data period.

53.   A method according to claim 52 wherein the MAC channel is used to transmit forward power control commands and reverse activity commands.

54.   A method according to claim 52 wherein:

          each voice user is assigned at least one group ID;

each data user is assigned a group ID;

a single group ID is transmitted on the preamble, so as to inform any user(s) having been assigned that group ID that the slot has content for the user.

5   55.   A method according to claim 54 wherein:

each voice user has three Group IDs, one GID1 for use when its voice is transmitted using one 16-ary Walsh cover, one GID2 for use when its voice is transmitted using two 16-ary Walsh covers, and one GID4 for use when its

10 voice is transmitted using four 16-ary Walsh covers;

wherein each user has Walsh covers assigned to it for each of the its three Group IDs such that when a given group ID is transmitted, then all voice users having been assigned the given group ID will know the slot contains

15 their content, will know how many Walsh codes recover and which Walsh codes to recover.

56.   A method according to claim 1 adapted to transmit data using parameters from any row of the table in Figure 5A.

57.   A method according to claim 1 adapted to transmit voice using parameters from any row of the table in Figure 5B.

58.   A method according to claim 1 adapted to transmit voice using parameters from any row of the table in Figure 5C.

59.   A method according to claim 1 adapted to transmit voice using parameters from any row of the table in Figure 5D.

60.   A method according to claim 2 adapted to transmit voice using parameters from any row of the table in Figure 12.

61.   A method according to claim 2 adapted to transmit data using parameters from any row of the table in Figure 13.

62.   A method according to claim 2 adapted to transmit data using parameters from any row of the table in Figure 14.

63.   A method of informing a particular user whether a current slot of a shared data channel contains data for the user, the method comprising:

        providing a user identification channel;

        transmitting a user identifier comprising a Walsh code and a sub-identifier.

64.   A method according to claim 63 wherein the sub-
identifier is an N bit identifier, and the Walsh code is
one of P M-ary Walsh codes.

65.   A method according to claim 64 wherein the user
5 identification channel is transmitted in K chip slots, and
has I and Q channels, thereby providing a 2*K/(M) bit
capacity, and an ability to transmit 2*K*M/N user
identifiers per slot.

66.   A method according to claim 65 wherein M=512,
10 K=1536, N=3 and P=16 thereby providing an ability to
transmit 32 user identifiers per slot, and an ability to
uniquely identify 128 different users.

67.   A method according to claim 65 wherein M=512,
K=1536, N=3 and P=8 thereby providing an ability to
15 transmit 16 user identifiers per slot, and an ability to
uniquely identify 64 different users.

68.   A method according to claim 63 wherein a voice
only user is assigned a single user identifier, and a user
with voice and data is assigned one user identifier for
20 data and one user identifier for voice.

69.   A method according to claim 63 wherein for a
given slot during which high-rate data is to be
transmitted, data is transmitted for a high-rate data user
likely to have good channel conditions during the slot.

25 70.   A method according to claim 63 further comprising
performing adaptive modulation and coding for high rate
data users based on channel estimates fed back every slot.

71.   A method of assigning voice Walsh codes
comprising:

assigning each voice user a voice channel number V (V=0,1,2...) which is used to calculate one or two 16-ary Walsh codes on which it will receive voice information;

using a Supplemental Paging Channel (SPCH) to
5 broadcast the number of 16-ary Walsh codes available for Data only shared channel slots (Nd) and the number of 16-ary Walsh codes available for Voice in Hybrid shared channel slots (Nv);

calculating the two Walsh codes for a particular
10 user, Wx116 and Wx216 according to X1=15-mod(V,Nv) and X2=15-mod(V+1,Nv).

72.   A wireless terminal adapted to function in a CDMA communications system, the terminal comprising:

a receiver adapted to receive frames having a
15 slot structure in which there is a user identification channel and a shared channel, the shared channel having been transmitted using a plurality of Walsh codes, and containing content for either a plurality of voice users, a plurality of voice users and one high-rate data user, or
20 only one high-rate data user;

the wireless terminal being adapted to decode the user identification channel to determine if a current slot of the shared channel contains voice and/or high-rate data content for the wireless terminal (voice content being
25 voice or low-rate data).

73.   A wireless terminal according to claim 72 wherein in the event the wireless terminal determines the current slot contains voice content for the wireless terminal, the receiver is adapted to blindly distinguishing between a

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plurality of different coding and modulation types which
may have been used to transmit the voice content based on
getting a correct CRC.

74.   A wireless terminal according to claim 72 adapted
5   to decode the user identifier channel using an assigned
user identifier Walsh and sub-identifier.

75.   A wireless terminal according to claim 72 adapted
to be assigned at least one group ID as a voice user and
adapted to be assigned a group ID as a data user;

10   wherein a single group ID is transmitted on a
preamble of each slot, so as to inform the wireless
terminal whether that the slot has content for the user.

76.   A wireless terminal according to claim 75 wherein
each voice user has three Group IDs, one GID1 for use when
15 its voice is transmitted using one 16-ary Walsh cover, one
GID2 for use when its voice is transmitted using two 16-ary
Walsh covers, and one GID4 for use when its voice is
transmitted using four 16-ary Walsh covers;

            wherein each user has Walsh covers assigned to it
20 for each of the its three Group IDs such that when a given
group ID is transmitted, then all voice users having been
assigned the given group ID will know the slot contains
their content, will know how many Walsh codes recover and
which Walsh codes to recover.

25 77.   A wireless terminal according to claim 70 further
adapted to perform fast ARQ for voice.

78.   A wireless terminal according to claim 72 adapted
to perform fast ARQ for voice by:

determining a correlation result based on the
user identifier channel;

if the correlation result is greater than a first
threshold and less than a second threshold, the wireless
5   terminal decoding further channels, and if these channels
pass an integrity check, sending an ACK to the base
station, and otherwise, the wireless terminal discarding
the current packet;

if the correlation result is greater than the
10   second threshold, the wireless terminal decoding further
channels, and if these channels pass an integrity check,
sending a ACK signal to the base station, and if these
channels do not pass the integrity check sending an NAK to
the base station.

15   79.   A wireless terminal according to claim 78 further
adapted to save current packet raw data samples for soft
combining or incremental redundancy with the future
received data packet.

80.   A wireless terminal according to claim 72 further
20   adapted to look for a single user identifier if the
terminal is expecting voice only, and if the terminal is
expecting voice and data, to look for two user identifiers,
one for voice and one for data.

81.   A wireless terminal according to claim 80 further
25   comprising:

in the event a current slot contains data for the
wireless terminal as determined by the user identification
channel, decoding another forward link channel to determine
parameters used in transmitting the data packet, and then

using a data rate determined from the another forward link
channel to demodulate the data on the shared channel.

82.   A wireless terminal according to claim 72 further
adapted to perform voice ARQ.

83.   A wireless terminal according to claim 82 adapted
to perform voice ARQ using a 1xRTT-like pilot channel.

84.   A wireless terminal according to claim 83 wherein
the 1xRTT-like pilot channel is further used to transmit a
RRI (reverse rate indicator).

85.   A wireless terminal according to claim 84 adapted
to perform voice ARQ by transmitting VARQ bits subject to:

         when functioning with a voice service only, the
VARQ valid bit positions are in slots 3,4,7,8,9,11,12,13
and 15 of a current frame and slots 0 and 1 of a next
frame, with slots 2, 6, 10 and 14 being reserved for RRI
(reverse rate indicator);

         when functioning in with both data and voice
services, the position for the VARQ is fixed within a frame
at slots 9 and 10, with remaining slots used for reverse
rate indicator.

86.   A wireless terminal according to claim 82 adapted
to:

         when functioning as a wireless terminal of a
mixed data and voice user, map each RRI (reverse rate
indicator) symbol (3 bits) to a simplex code with length of
7 repeated twice and mapped to slots 0-8 and 11-15, with
voice ARQ being one bit mapped into slot 9 and 10, the RRI
being used to indicate whether the Reverse Dedicated

Control Channel or Reverse Supplemental Channel or neither
is active for the current frame;

when functioning as a wireless terminal of a
voice only users, map the RRI bit to slots 2, 6, 10 and 12,
5   with the voice ARQ being one bit mapped into any two
consecutive slots that are not reserved for RRI.

87.   A wireless terminal according to claim 82 further
adapted to transmit a Channel Estimate and Sector Selector
(R-CHESS) channel having a slot for each forward slot, with
10   some slots containing channel estimates and other slots
containing sector select values.

88.   A wireless terminal according to claim 87 wherein
the CHESS channel is adapted to allow sector selection for
data users which precludes the changing from a sector value
15   directly to another sector value, only allowing a change
from a sector value to a null value and then to another
sector value.

89.   A wireless terminal according to claim 88 wherein
if the sector select value changes from a first sector
20   value to a null value, the wireless terminal is adapted to
continue to report channel estimates for the first sector
value for a number of subsequent slots;

when the sector select value changes to a
different sector value, the wireless terminal starts to
25   report channel estimates for this new sector.

90.   A wireless terminal according to claim 87 wherein
each channel estimate comprises a three bit value
representative of an absolute channel estimate.

91.   A wireless terminal according to claim 87 wherein
the channel estimates comprise three bit values alternating
between being representative of an absolute channel
estimate and a change in channel estimate.

5   92.   A wireless terminal according to claim 87
wherein:

        sector select values are sent during the first
and ninth of sixteen available CHESS channel slots, and
channel estimates are sent during the remaining of the
10   slots.

93.   A wireless terminal according to claim 72 adapted
to process packets sent on a shared channel providing
systematic predetermined incremental redundancy symbol
selection for voice and data in which an even second timing
15   referenced to UTC (Universal Coordinated Time) has been
used to select a portion of turbo coded data symbols to be
sent in a given slot, a count value k is used which starts
on each even second which counts from $k = 0$ to Kmax
incrementing every (even second interval)/K; starting (i1)
20   and ending (i2) symbol positions are calculated of a actual
Turbo transmitted packet are from $i1 = 1 + mod(kL, M)$, $i2 =
i1 + L-1$, the Turbo coded packet being viewed as a periodic
signal with period M, where N is the user payload packet
size in number of symbols, M is the coded packet size,
25   which is the packed size (in number of symbols) after Turbo
coding, and L is the actual transmitted packet size in
number of symbols resulting in an effective coding rate
would be N/L, the wireless terminal being adapted to
process the packets by:

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deriving packet size information, and using the count value, determining which portion of the turbo coded packet the received packet belongs to.

94.   A wireless terminal according to claim 93 further
5 adapted to decode the packet and performing a quality check on decoded packet;

if the decoded result does not pass the quality check, check if the previous received packet was decoded correct or not;

10   if the previous received packet is wrong, the current received packet will be used for soft combining and/or incremental redundancy with the previous received packet;

if the previous received packet is correct or the
15 joint decoded result is wrong, a NAK signal is sent to the base station, and the current received packet will be stored and may be used for soft combining and/or incremental redundancy with the future received packet.

95.   A wireless terminal according to claim 72 adapted
20 to transmit supplementary channel(s) according to parameters in any row of the tables in Figure 22 and Figure 23.

96.   A method for time division multiplexing of reverse supplemental channel and reverse control channel,
25 said method comprising:

multiplexing said a supplemental channel and a control channel;

indicating, via a reverse rate indicator (RRI), whether a supplemental channel or a control channel or neither is active;

wherein said method enables sharing of channels by physical resources in wireless terminal modems and base station modems.
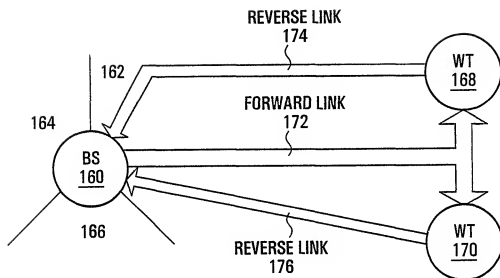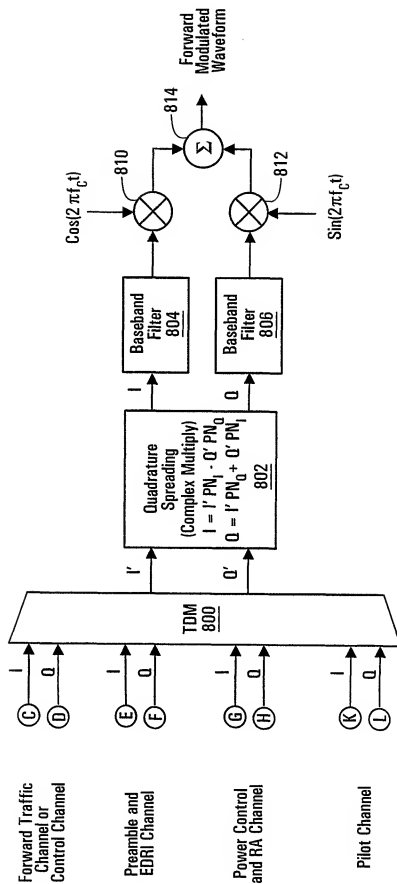
1/32

FIG. 1A

FIG. 1B

FIG. 1C
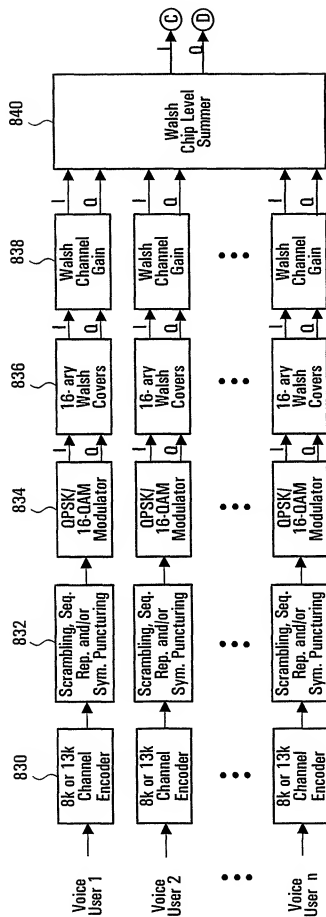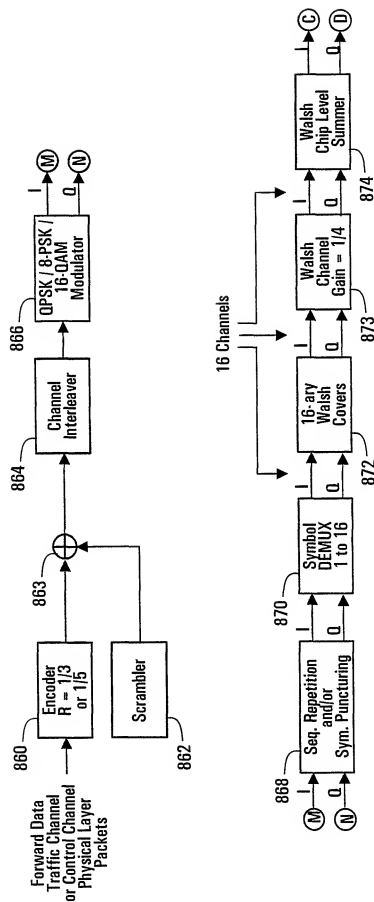
FIG. 1D

FIG. 1E

FIG. 1F

FIG. 1G

FIG. 2

A SLOT ON THE FORWARD LINK

Active Mode — 100

768chips | 160chips | 768chips

Data(304chips) 104
Pilot 106 — 108 — 96chips
Data(304chips) 110 — 112
Data(304chips) 114
32chips
Pilot 116 — 118 — 96chips
32chips
Data(304chips) 120 — 122
32chips
768chips

Idle Mode — 102

32chips
Pilot 106 — 110 — 108 — 96chips
32chips
Pilot 116 — 120 — 118 — 96chips

120

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FIG. 3

FIG. 4

FIG. 5A
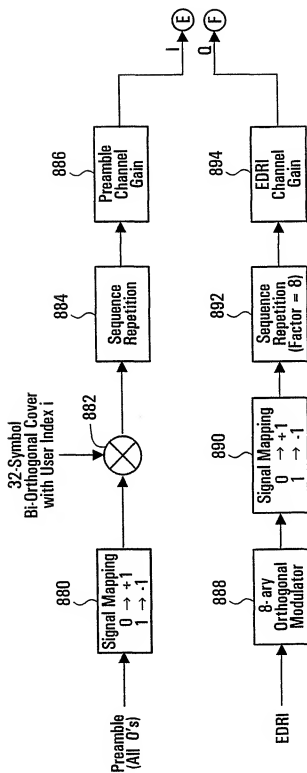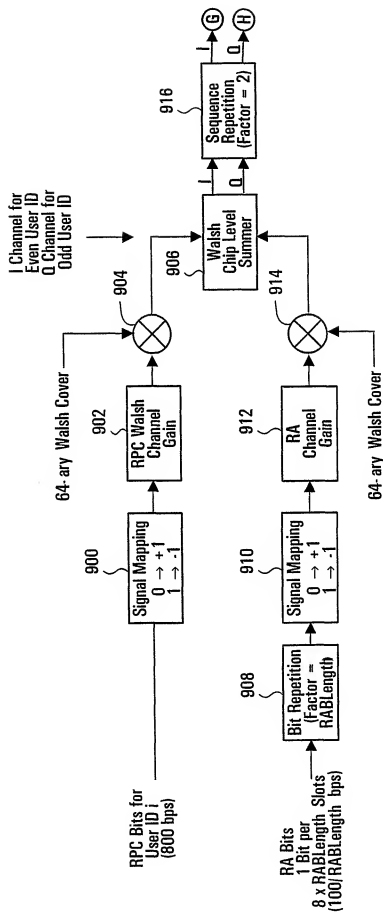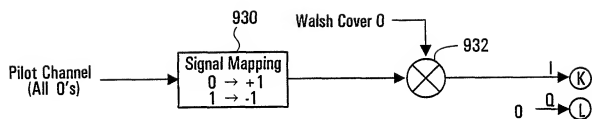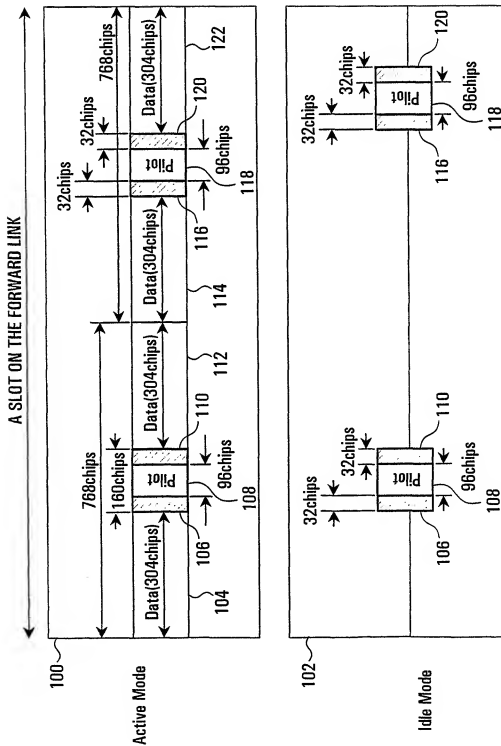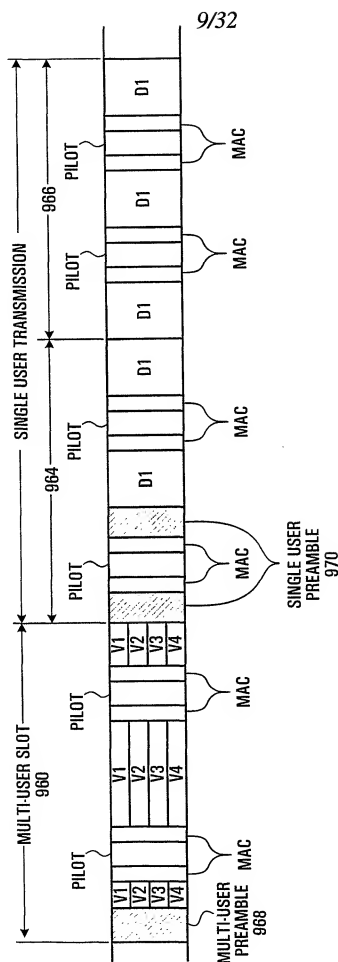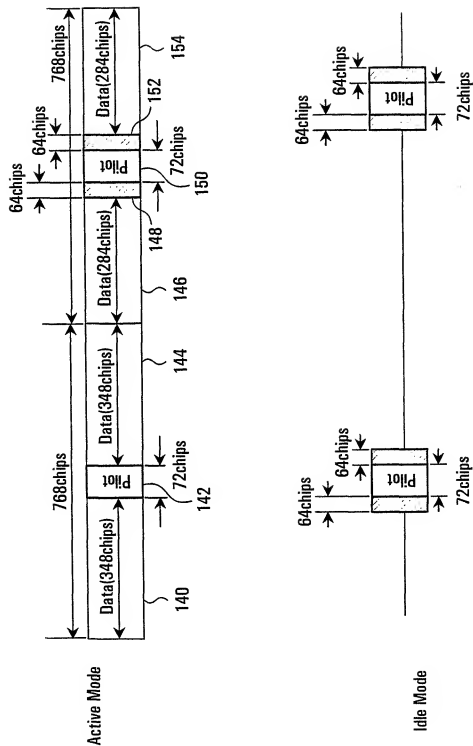
FL PHYSICAL LAYER PARAMETERS (DATA)

Data Rate (kbps)	Slots	Bits	Code Rate	Modulation	Modu. Symbols Provided	Repetition Factor	Approx Coding Rate	Preamble Chips	Pilot Chips	MAC Chips	Data Chips
					Number of Values per Physical Layer Packet						
38.4	16	768	1/5	QPSK	1,920	9.6	1/5	1,024	3,072	2,048	18,432
76.8	8	768	1/5	QPSK	1,920	4.8	1/5	512	1,536	1,024	9,216
153.6	4	768	1/5	QPSK	1,920	2.4	1/5	256	768	512	4,608
307.2	2	768	1/5	QPSK	1,920	1.2	1/5	128	384	256	2,304
614.4	1	768	1/3	QPSK	1,152	1	1/3	64 w EDRI	192	128	1,152
614.4	2	1536	1/3	QPSK	2,304	1	1/3	2x64 w EDRI	384	256	2,304
1,228.8	1	1536	1/3	QPSK	2,304	1	2/3	64 w EDRI	192	128	1,152
921.6	2	2304	1/3	8-PSK	2,304	1	1/3	2x64 w EDRI	384	256	2,304
1,843.2	1	2304	1/3	8-PSK	1,152	1	2/3	64 w EDRI	192	128	1,152
1,228.8	2	3072	1/3	16-QAM	2,304	1	1/3	2x64 w EDRI	384	256	1,152
2,457.6	1	3072	1/3	16-QAM	2,304	1	2/3	64 w EDRI	192	128	1,152

FL PHYSICAL LAYER PARAMETERS FOR VOICE (1)

Vocoder	Rate	Bits	Code Rate	Modulation	Modulation Symbols Needed	Approx Coding Rate	Preamble Chips	Pilot Chips	MAC Chips	Data Chips
8k	Full	184	1/3	16-QAM	72	0.64	64	192	128	1,152
	1/2	88	1/3	QPSK	72	0.61	64	192	128	1,152
	1/4	46	1/3	QPSK	72	0.32	64	192	128	1,152
	1/8	22	1/3	QPSK	72	0.15	64	192	128	1,152
13k	Full	279	1/3	16-QAM	72	0.97	64	192	128	1,152
	1/2	135	1/3	16-QAM	72	0.47	64	192	128	1,152
	1/4	63	1/3	QPSK	72	0.44	64	192	128	1,152
	1/8	27	1/3	QPSK	72	0.19	64	192	128	1,152

Number of Values per Physical Layer Packet

FIG. 5B

FL PHYSICAL LAYER PARAMETERS FOR VOICE (2)

Number of Values per Physical Layer Packet

Vocoder	Rate	Bits	Code Rate	Modulation	Modulation Symbols Needed	Coding Rate	Preamble Chips	Pilot Chips	MAC Chips	Data Chips
8k	full	184	1/3	QPSK	136	0.68	128	192	128	1,088
	1/2	88	1/3	QPSK	136	0.32	128	192	128	1,088
	1/4	46	1/3	QPSK	136	0.17	128	192	128	1,088
	1/8	22	1/3	QPSK	136	0.08	128	192	128	1,088
13k	Full	279	1/3	16-QAM	136	0.51	128	192	128	1,088
	1/2	135	1/3	QPSK	136	0.5	128	192	128	1,088
	1/4	63	1/3	QPSK	136	0.23	128	192	128	1,088
	1/8	27	1/3	QPSK	136	0.1	128	192	128	1,088

FIG. 5C

FL PHYSICAL LAYER PARAMETERS FOR VOICE (3)

Vocoder	Rate	Bits	Code Rate	Modulation	Modulation Symbols Needed	Coding Rate	Preamble Chips	Pilot Chips	MAC Chips	Data Chips
8k	Full	184	1/3	QPSK	240	0.38	256	192	128	960
	1/2	88	1/3	QPSK	240	0.18	256	192	128	960
	1/4	46	1/3	QPSK	240	0.10	256	192	128	960
	1/8	22	1/3	QPSK	240	0.05	256	192	128	960
13k	Full	279	1/3	QPSK	240	0.58	256	192	128	960
	1/2	135	1/3	QPSK	240	0.28	256	192	128	960
	1/4	63	1/3	QPSK	240	0.13	256	192	128	960
	1/8	27	1/3	QPSK	240	0.06	256	192	128	960

Number of Values per Physical Layer Packet

FIG. 5D
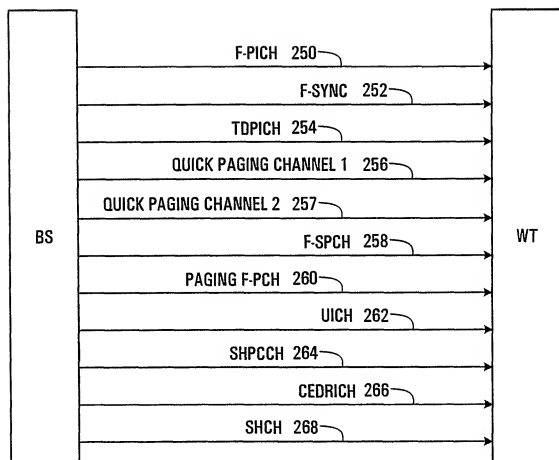
FIG. 6
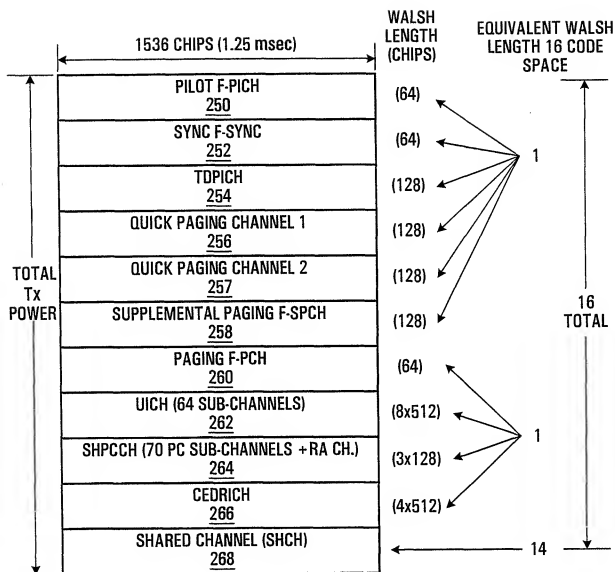
FIG. 7
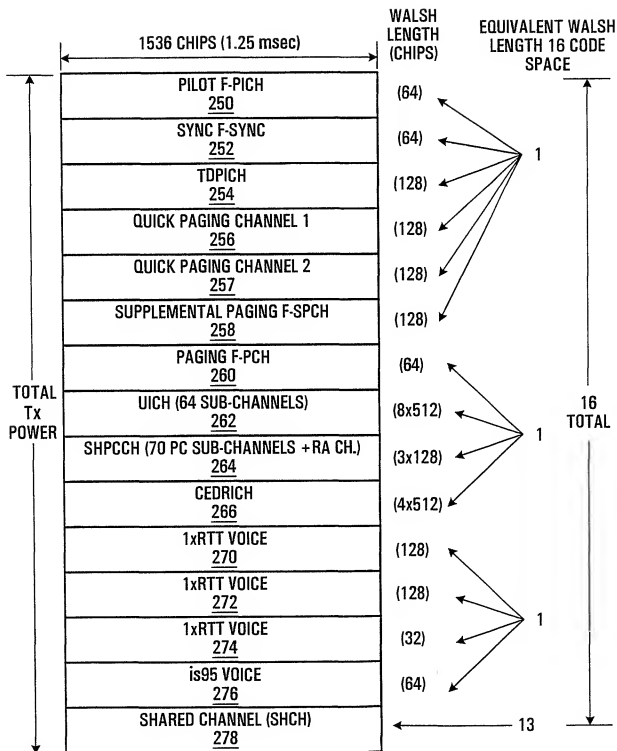
FIG. 8

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FORWARD LINK SLOT STRUCTURE

| CHANNEL	WALSH CODES	
IS-95 F-PICH	W_0^{64}	W_0^{16}
IS-95 F-SYNC	W_{32}^{64}	
IS-2000 F-TDPICH	W_{16}^{128}	
IS-2000 F-QPCH 1	W_{80}^{128}	
IS-2000 F-QPCH 2	W_{48}^{128}	
F-SPCH INSTEAD OF IS-2000 F-QPCH3	W_{112}^{128}	
IS-95 F-PCH	W_1^{64}	W_1^{16}
F-UICH (64 USERS)	$W_{33}^{512}, W_{289}^{512}, W_{161}^{512}, W_{317}^{512},$ $W_{97}^{512}, W_{353}^{512}, W_{225}^{512}, W_{481}^{512}$	
F-SHPCCH (70 USERS) PLUS IFLEX-DV F-RA CHANNEL	$W_{17}^{128}, W_{81}^{128}, W_{49}^{128}$	
F-CEDRICH	$W_{113}^{512}, W_{369}^{512}, W_{241}^{512}, W_{497}^{512},$	
F-SHCH	$W_2^{16}, W_3^{16}, \quad W_{15}^{16}$	

FIG. 9
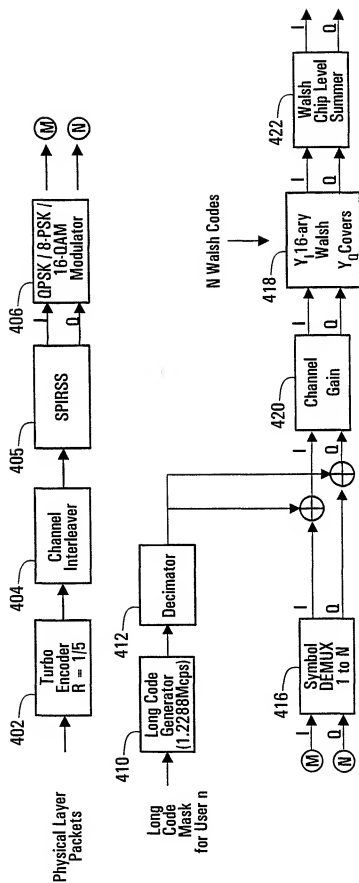
FIG. 10

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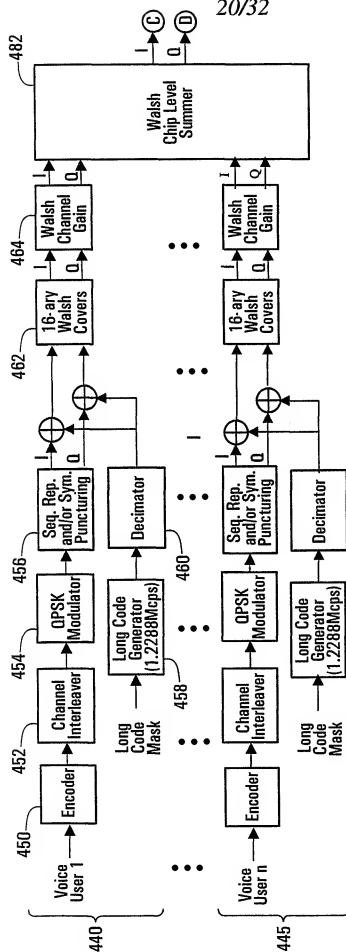
FIG. 11

FORWARD LINK SHCH VOICE PARAMETERS

CODE TYPE	# W¹⁶ USED	RATE	BITS	CODE RATE	MODULATION	MODULATION ON SYMBOLS NEEDED	MODULATION ON SYMBOLS PROVIDED	APPROX. CODDING RATE
TURBO	1	FULL	192	1/5	8-PSK	96	320	0.67
CONV	1	1/2	96	1/4	QPSK	96	192	0.50
CONV	1	1/4	54	1/4	QPSK	96	108	0.28
CONV	1	1/8	30	1/4	QPSK	96	60	0.16
TURBO	2	FULL	192	1/5	QPSK	192	480	0.50

FIG. 12

FORWARD LINK SHCH DATA PARAMETERS (1)

Data Rate (kbps)	Packet Size	No. of Walsh Codes	No. of Slots	Code Rate	Modulation Order	Mod Symbols Needed	Mod Symbols Provided	Effective Code Rate
4915.2	6144	14	1	0.2	6	1344	5120	0.761905
2457.6	3072	14	1	0.2	4	1344	3840	0.571429
1228.8	1536	14	1	0.2	3	1344	2560	0.380952
614.4	768	14	1	0.2	6	1344	1920	0.285714
2457.6	3072	10	1	0.2	4	960	2560	0.533333
1228.8	1536	10	1	0.2	2	960	1920	0.4
614.4	768	10	1	0.2	2	960	1920	0.4
307.2	384	10	1	0.2	2	960	960	0.2
2457.6	3072	7	1	0.2	6	672	2560	0.761905
1228.8	1536	7	1	0.2	4	672	1920	0.571429
614.4	768	7	1	0.2	2	672	1920	0.571429
307.2	384	7	1	0.2	2	672	960	0.285714
1228.8	1536	4	1	0.2	6	384	1280	0.666667
614.4	768	4	1	0.2	4	384	960	0.5
307.2	384	4	1	0.2	2	384	960	0.5
614.4	768	3	1	0.2	4	288	960	0.666667
307.2	384	3	1	0.2	2	288	960	0.666667
614.4	768	2	1	0.2	6	192	640	0.666667
307.2	384	2	1	0.2	3	192	640	0.666667
153.6	192	2	1	0.2	2	192	480	0.5
153.6	192	1	1	0.2	3	96	320	0.666667

FIG. 13

FORWARD LINK SHCH DATA PARAMETERS (2)

Data Rate [kbps]	Packet Size	No. of Walsh Codes	No. of Slots	Code Rate	Modulation Order	Mod Symbols Needed	Mod Symbols Provided	Effective Code Rate
1228.8	3072	14	2	0.2	3	2688	5120	0.380952
614.4	1536	14	2	0.2	3	2688	2560	0.190476
307.2	768	14	2	0.2	2	2688	1920	0.142857
153.6	384	14	4	0.2	2	2688	960	0.071429
614.4	3072	14	4	0.2	2	5376	7680	0.285714
307.2	1536	14	4	0.2	2	5376	3840	0.142857
153.6	768	14	4	0.2	2	5376	1920	0.071429
76.8	384	14	4	0.2	4	5376	960	0.035714
1228.8	3072	10	2	0.2	4	1920	3840	0.4
614.4	1536	10	2	0.2	3	1920	2560	0.266667
307.2	768	10	2	0.2	2	1920	1920	0.2
153.6	384	10	2	0.2	2	1920	960	0.1
614.4	3072	10	4	0.2	2	3840	7680	0.4
307.2	1536	10	4	0.2	2	3840	3840	0.2
153.6	768	10	4	0.2	2	3840	1920	0.1
76.8	384	10	4	0.2	6	3840	960	0.05
307.2	768	1	2	0.2	3	192	640	0.666667
153.6	384	1	2	0.2	6	192	640	0.666667
76.8	192	1	2	0.2	3	192	480	0.5
307.2	1536	1	4	0.2	6	384	1280	0.666667
153.6	768	1	4	0.2	2	384	1280	0.666667
76.8	384	1	4	0.2	2	384	960	0.5
38.4	192	1	4	0.2	2	384	480	0.25

FIG. 14
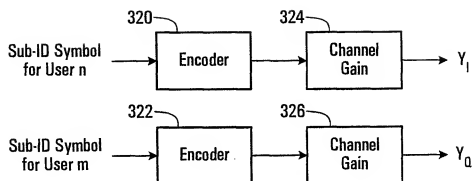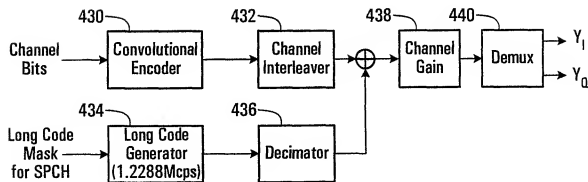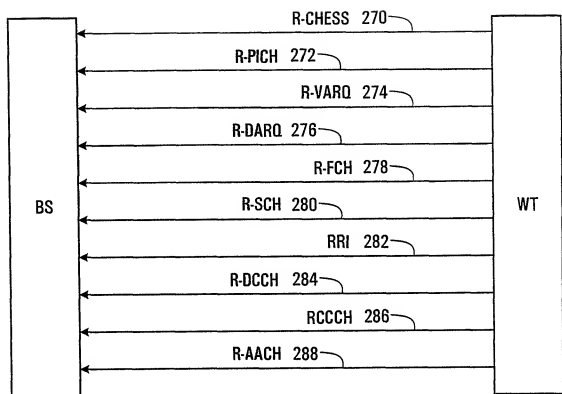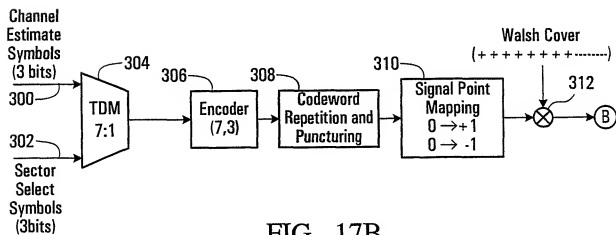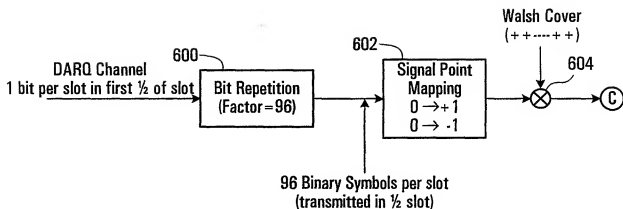
FIG. 15

FIG. 16

FIG. 17A

FIG. 17B

FIG. 18

FIG. 19
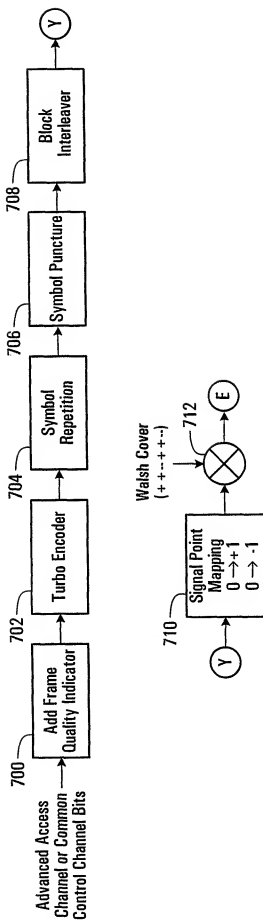
FIG. 20

FIG. 21A

FIG. 21B

FIG. 21C

REVERSE SCH CODING AND MODULATION PARAMETERS 1

Reverse Rate Index	1 (DCCH)	2	3	4	5	6	7
Data Rate (kbps)	9.6	4.8	9.6	19.2	38.4	76.8	153.6
Encoder Packet Size (bits)	184	88	184	376	760	1528	3064
Code Rate (bit/sym)	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Code Symbols/Packet	1536	1536	1536	1536	3072	6144	12288
Code Symbol Rate (ksps)	76.8	76.8	76.8	76.8	153.6	307.2	614.4
Interleaved Packet Repeats	2	4	2	1	1	1	1
Data Modulation	BPSK	BPSK	BPSK	BPSK	BPSK	BPSK	BPSK
PN Chips per Encoder bit	128	256	128	64	32	16	8
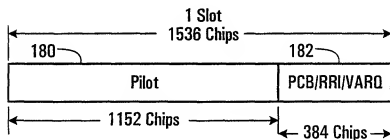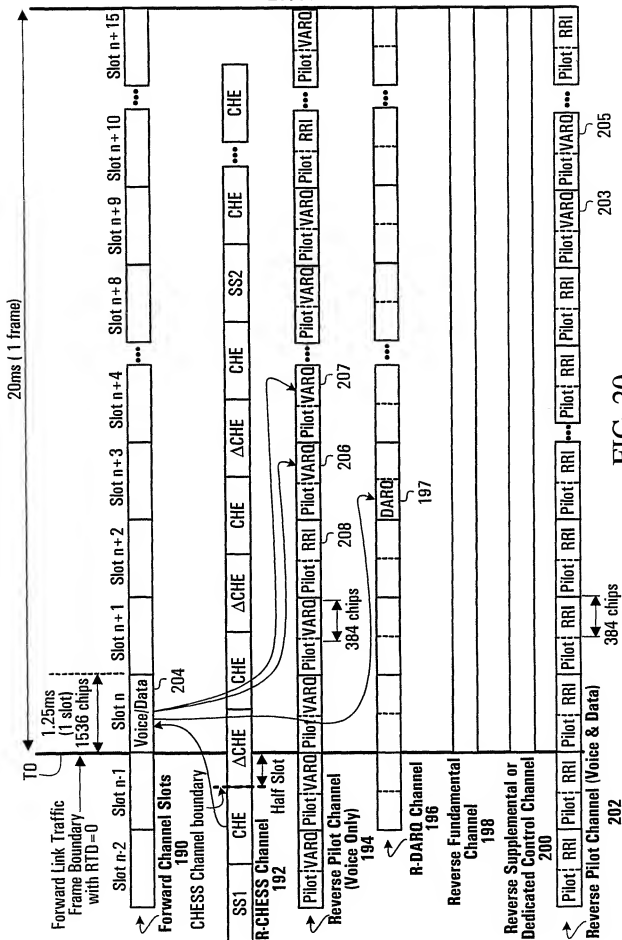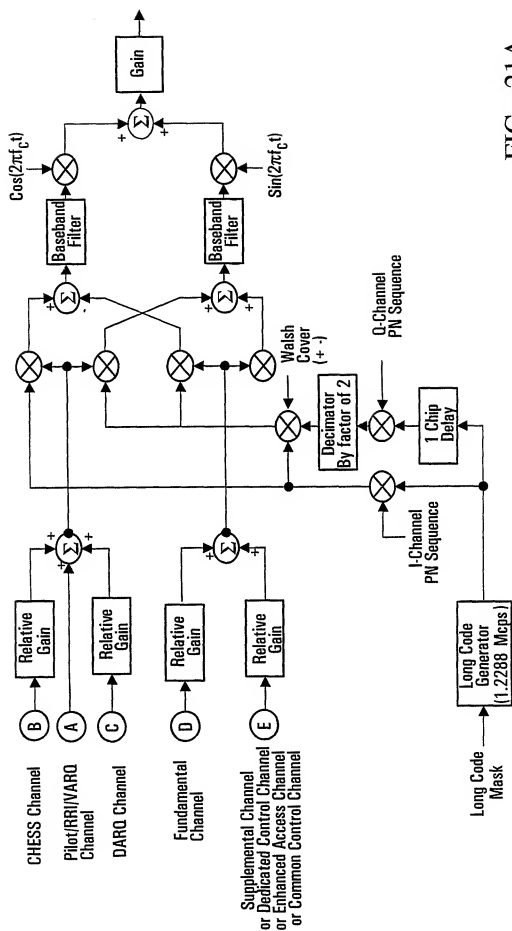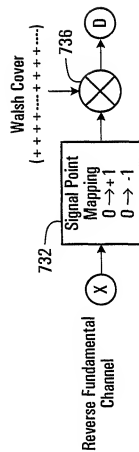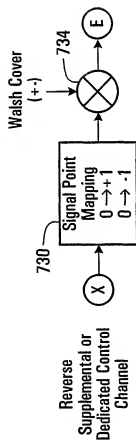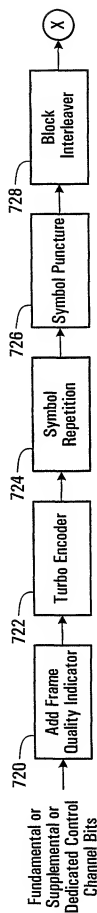
FIG. 22

REVERSE SCH CODING AND MODULATION PARAMETERS 2

Reverse Rate Index	1 (DCCH)	2	3	4	5	6	7
Data Rate (kbps)	9.6	4.8	38.4	76.8	153.6	307.2	614.4
Encoder Packet Size (bits)	184	88	760	1528	3064	6136	12272
Code Rate (bit/sym)	0.25	0.25	0.25	0.25	0.25	0.5	1
Code Symbols/Packet	1536	1536	3072	6144	12288	12288	12288
Code Symbol Rate (kbps)	76.8	76.8	153.6	307.2	614.4	614.4	614.4
Interleaved Packet Repeats	2	4	1	1	1	1	1
Data Modulation	BPSK	BPSK	BPSK	BPSK	BPSK	BPSK	BPSK
PN Chips per Encoder bit	128	256	32	16	8	4	2

FIG. 23